Project co-financed by the European Regional Development Fund

Acronym: AMAre

Project Title: AMAre - Actions for Marine Protected Areas

Priority Axis 3: Protecting and promoting Mediterranean natural and cultural resources

Specific Objective: 3.2 To maintain biodiversity and natural ecosystems through strengthening the management and networking of protected areas

https://amare.interreg-med.eu/

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Name of Activity: Oceanographic data and indicators for MPAs

Title of Deliverable: Databases of Oceanographic products and indicators

Work Package Number: 3

AMAre Horizontal Project

Involved partners:

Euro-Mediterranean Centre on Climate Change Foundation (CMCC)

National Research Council (CNR)

National Inter-University Consortium for Marine Sciences (CoNISMa)

University of Malta (UoM)

Regional Government of the Balearic Islands

Management Body of the National Marine Park of Alonissos Northern Sporades

Management Consortium of Torre Guaceto

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Table of Contents

List of abbreviations and terms

AFS	Adriatic Forecasting System
BA	Baleares
BFM	Biogeochemical Flux Model
CHL	Chlorophyll
CMCC	Euro-Mediterranean Centre on Climate Change Foundation
CMEMS	Copernicus Marine Environment Monitoring Service
CoNISMa	National Inter-University Consortium for Marine Sciences
FTP	File Transfer Protocol
GOS	Global Ocean Satellite
IBI	Iberia-Biscay-Ireland Forecasting System
INGV	Istituto Nazionale di Geofisica e Vulcanologia
ISAC	Istituto di Scienze dell'Atmosfera e del Clima
MA	Malta
MFS	Mediterranean Forecasting System
mm	Monthly mean
NUT	Nutrients
OGS	Istituto Nazionale di Oceanografia e Geofisica Sperimentale
OXY	Oxygen
OXYb	Oxygen at sea floor
Rrs	Remote Sensing Reflectance
sat	satellite
sm	Seasonal mean
SSC	Sea Surface Currents
SSS	Sea Surface Salinity
SST	Sea Surface Temperature
SP	Sporades
TG	Torre Guaceto
TRA	Trasparency
UM	University of Malta
ym	Yearly mean

1 Introduction

The main objective of WP3 is to develop shared methodologies and geospatial tools for multiple stressors assessment, coordinated environmental monitoring, multi-criteria analyses and stakeholders' engagements to launch pilot activities followed by a wider process of capitalization, dissemination and transfer of experiences and results.

In the framework of WP3, CMCC Foundation is coordinating the following Activity:

- 3.4: Oceanographic data and indicators for MPAs

with the aim to develop oceanographic products and indicators to support project MPAs environmental assessment and management.

In this document are described the best oceanographic data available nowadays for the environmental monitoring of MPAs involved into the project. They are:

- sea surface temperature,
- sea surface currents,
- sea surface salinity,
- chl-a concentration,
- nutrients concentration,
- transparency of water column,
- dissolved oxygen concentration.

The maximum spatial resolution reached is about 1km, obtained with remote sensing, far enough from the requirement when considering coastal zones. Furthermore, satellite data cover only the sea surface and, to obtain information on the water column, 3D numerical model data are needed.

The oceanographic climatologies (long term time average fields) provided for project purposes consider different time intervals being able to be coupled with biological time series.

In the next months of project activities, MSFD and marine assessment related physical ocean indicators (trends, upwelling indices, stratification indices, etc.) will be further developed and provided. Furthermore, in order to help a fruitful planning of monitoring and sampling activities in AMAre MPAs, short-term forecast will be provided for the environmental variables of interest.

The collection of in-situ data into MPAs will be of crucial importance to obtain specific local information into those coastal zones, not available now, and to validate the high resolution numerical models in order to provide more realistic results in a near future.

Oceanographic products are based on Mediterranean Monitoring and Forecasting Centre products provided by the European Service Copernicus and on high-resolution products provided by the Oceanographic Centers (CMCC, CoNISMa, University of Malta) involved into AMAre project.

All the oceanographic data are linked to the GeoDatabase of the project for their visualization on the GeoPortal and freely available to the users via a password protected ftp service available at the link ftp.oclab.cmcc.it/amare. In the next months of activities, the GeoPortal will provide different online services in order to analyze the available data.

2 Oceanographic products

The oceanographic data provided for AMAre purposes have two main sources: satellite and numerical models.

All products are delivered as long time series of monthly, seasonal and yearly means of selected surface sea variables, with different spatial resolution, covering the following MPAs areas:

- Baleares: 38.54°N - 38.99°N, 1.21°E - 1.64°E;
- Malta: 35.83°N - 36.19°N, 14.13°E - 14.61°E;
- Sporades: 38.89°N - 39.69°N, 23.74°E - 24.53°E;
- Torre Guaceto: 40.59°N - 40.86°N, 17.66°E - 17.96°E.

For each above-mentioned MPA, a buffer of 10km has been considered in order to include the ocean dynamics that can affect the seawaters enclosed into the protected areas.

2.1 Satellite data

2.1.1 Chlorophyll

Chlorophyll concentration data, retrieved by satellite, are provided by CMEMS (http://marine.copernicus.eu/) for whole Mediterranean Sea.

Two datasets have been considered for AMAre project:

a) OCEANCOLOUR_MED_CHL_L4_REP_OBSERVATIONS_009_078,
b) OCEANCOLOUR_MED_CHL_L4_NRT_OBSERVATIONS_009_041.

Dataset *a)* covers September 1997 - December 2015 period. Starting from Remote Sensing Reflectance (Rrs) spectrum, computed with the ESA-CCI technique for Copernicus at high resolution (1 Km), surface Chlorophyll concentration (mg m-3, 1 km resolution) is computed via regional algorithms.

Dataset *b)* covers January 2016 – nowadays period. Starting from the multi-sensor (MODIS-Aqua and NPP-VIIRS) and single sensor Sentinel3-OLCI Level-3 chlorophyll concentration, Level-4 product includes both time averaged (8-days and monthly) datasets and the daily interpolated chlorophyll field with no data voids (excluding OLCI dataset), all at 1 km spatial resolution.

The Group for Satellite Oceanography (GOS-ISAC) of the Italian National Research Council (CNR, Rome) operationally distributes these datasets using specific algorithms for offshore (Case 1) and coastal (Case 2) waters. For Case 1 waters, an updated version of the algorithm reported in Volpe et al. (2007), has been adopted; for Case 2 waters type the AD4 algorithm (DAlimonte and Zibordi, 2003) has been adopted instead. Units are expressed in mg/m^3.

A detailed description of the calibration and validation activities performed over these products can be found on the CMEMS web portal.

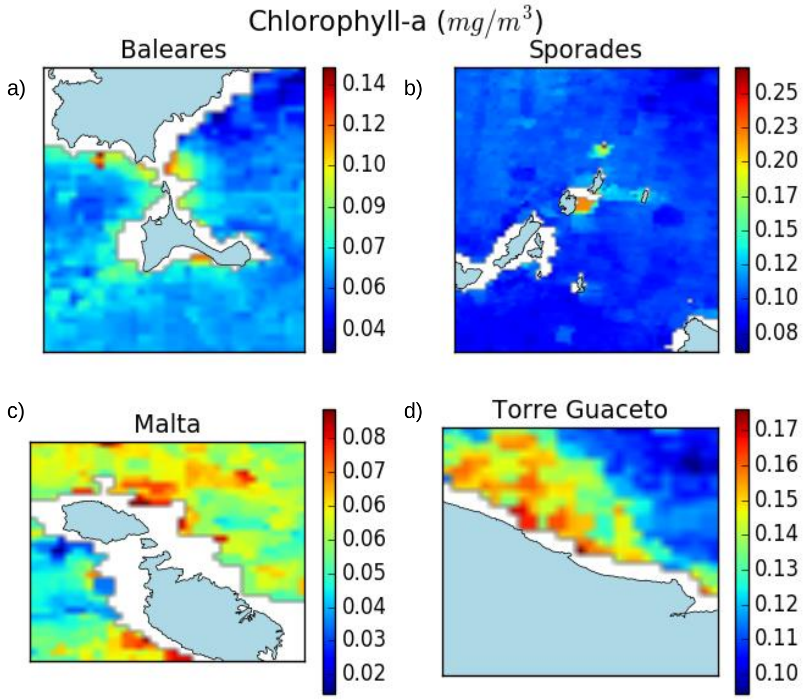

Figure 1 CHL-a concentration [mg m-3] retrieved by satellite for: a) Baleares, b) Sporades, c) Malta, d) Torre Guaceto.

The two datasets are provided to MPAs as:

- monthly means, covering the period 09/1997 – 12/2017
- seasonal means, covering the period 09/1997 – 12/2017
- yearly means, covering the period 1998 – 2017 years.

2.1.2 Water Transparency

Water transparency data, retrieved by satellite, are provided by CMEMS (http://marine.copernicus.eu/) for whole Mediterranean Sea.

Two datasets have been considered for AMAre project:

a) OCEANCOLOUR_MED_OPTICS_L3_REP_OBSERVATIONS_009_095,
b) OCEANCOLOUR_MED_OPTICS_L4_NRT_OBSERVATIONS_009_039.

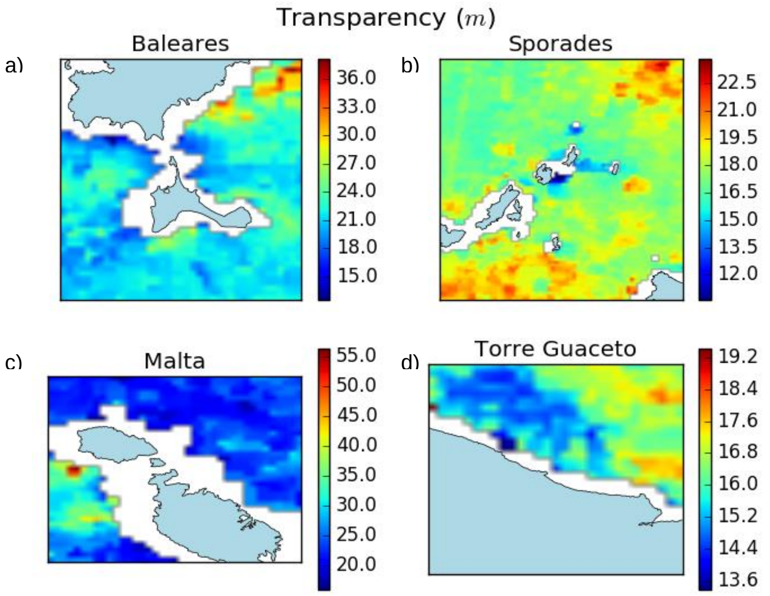

Figure 2 Transparency of water [m] retrieved by satellite for: a) Baleares, b) Sporades, c) Malta, d) Torre Guaceto

Dataset *a)* covers September 1997 – December 2015 period. Remote Sensing Reflectances (Rrs) and diffuse attenuation coefficient of light at 490 nm (kd490) data, computed with the ESA-CCI technique for CMEMS at 1 Km resolution, are operationally distributed by the Group for Satellite Oceanography (GOS-ISAC) of the Italian National Research Council (CNR), in Rome. Rrs (computed by PML) results from the merging of SeaWiFS, MODIS-Aqua, MERIS and VIIRS sensors.

Dataset *b)* covers January 2015 – nowadays period. The diffuse attenuation coefficient of light at 490 nm is operationally produced by the Group for Satellite Oceanography (GOS-ISAC) of the Italian National Research Council, in Rome. Data derive from the merging exercise of MODIS-Aqua and NPP-VIIRS data and separately at present for Sentinel3-OLCI. The Level-4 data are the time averages at monthly and 8-days time scales and include the standard deviation and the number of observations.

Rrs is defined as the ratio of upwelling radiance and downwelling irradiance at any wavelength (412, 443, 490, 555, and 670 nm), and can also be expressed as the ratio of normalized water leaving Radiance (nLw) and the extra-terrestrial solar irradiance (F0). Kd490 is defined as the diffuse attenuation coefficient of light at 490 nm, and is a measure of the turbidity of the water column, i.e., how visible light in the blue-green region of the spectrum penetrates within the water column. It is directly related to the presence of scattering particles in the water column and is estimated through the ratio between Rrs at 490 and 555 nm.

A detailed description of the calibration and validation activities performed over these products can be found on the CMEMS web portal.

The two datasets are provided to MPAs as:

- monthly means: 09/1997 – 12/2017
- seasonal means: 09/1997 – 12/2017
- yearly means: 1998 -2017

2.1.3 Sea Surface Temperature

Sea Surface Temperature data, retrieved by satellite, are provided by CMEMS (http://marine.copernicus.eu/) for whole Mediterranean Sea.

Two datasets have been considered for AMAre project:

a) SST_MED_SST_L4_REP_OBSERVATIONS_010_021,
b) SST_MED_SST_L4_NRT_OBSERVATIONS_010_004.

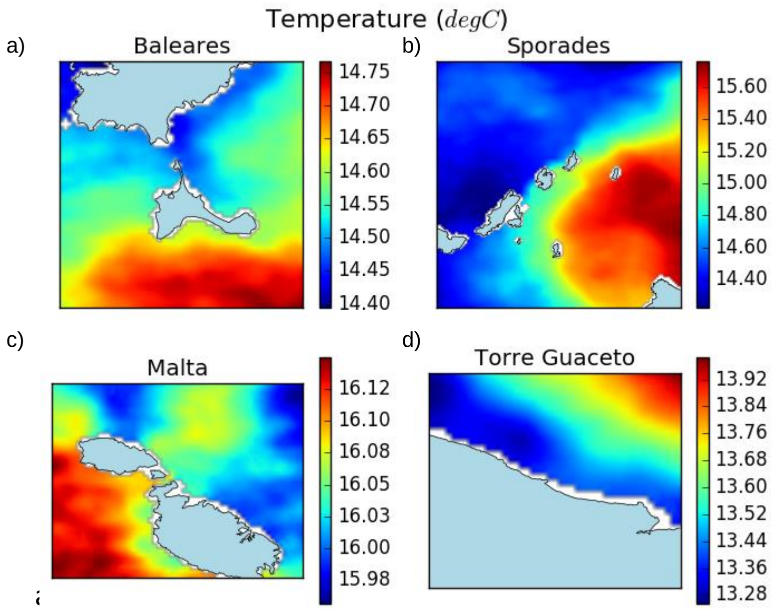

Figure 3 Sea surface temperature [degC] retrieved by satellite for: a) Baleares, b) Sporades, c) Malta, d) Torre Guaceto

Dataset *a)* covers January 1982 – December 2016 period. This reprocessing (REP) product is based on AVHRR Pathfinder Version 5.2 (PFV52) data set obtained from the US National Oceanographic Data Center and GHRSST (http://pathfinder.nodc.noaa.gov). The PFV5.2 data are an updated version of the Pathfinder Version 5.0 and 5.1 collections described in Casey et al. (2010). REP L4 data were interpolated on the original Pathfinder grid (at 0.0417° x 0.0417°spatial resolution) and representative of night SST values (00:00 UTC).

Dataset *b)* covers January 2008 – nowadays period. This SST product is based on the night-time images collected by the infrared sensors mounted on different satellite platforms, and covers the Mediterranean Sea. The ISAC-GOS processing chain includes several modules, from the data extraction and preliminary quality control, to cloudy pixel removal and satellite images collating/merging. A two-step algorithm finally allows interpolating SST data at ultra-high (UHR 0.01°) spatial resolution, applying statistical techniques.

A detailed description of the calibration and validation activities performed over these products can be found on the CMEMS web portal.

The two datasets are provided to MPAs as:

- monthly means: 01/1982 – 12/2017
- seasonal means: 01/1982 – 12/2017
- yearly means: 1982 -2017

2.2 Simulated data

2.2.1 Sea Surface Temperature

2.2.1.1 AFS, Adriatic Forecasting System

Sea Surface Temperature has been simulated for a long time period, 2003-2017 years, at high resolution (about 2.2km) for Torre Guaceto MPA with AFS, the Adriatic Forecasting System.

AFS has been developed by INGV in 2003 (Oddo et al. 2005, 2006, Guarnieri et al. 2008) and it is operational at CMCC since 2012. It is based on POM model that has been implemented in the Adriatic Sea with the domain encompassing the whole basin extending South of the Otranto channel into the Northern Ionian Sea, where the only open boundary is located. AFS has a horizontal resolution of about 1/45° on 31 σ-layers.

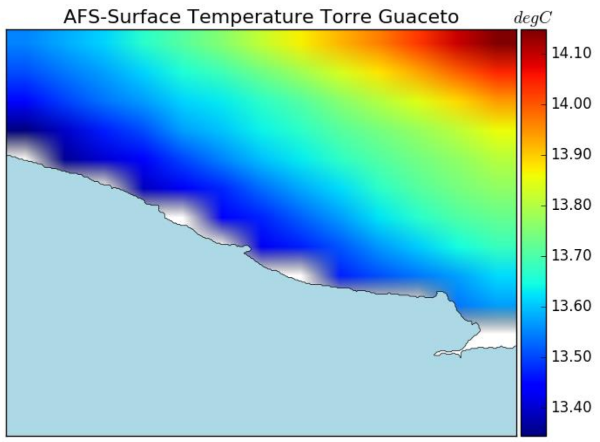

Figure 4 Sea surface temperature [degC] simulated by AFS for Torre Guaceto MPA

The surface fluxes are interactively computed using model predicted sea surface temperature and realistic atmospheric data provided by the European Centre for Medium Range Weather Forecast (ECMWF) with a frequency of six hours and a resolution of 0.125°. Realistic fresh water has been implemented in the surface boundary condition for the vertical velocity. The river input into the basin has been implemented through river climatology (Raicich, 1994) for all the rivers except for the Po, which is a very important forcing for the Adriatic Sea. The Po runoff implemented is on a daily basis.

The initial and lateral boundary conditions for temperature, salinity and velocity come from the Mediterranean Forecasting System, MFS (Pinardi et al, 2003, Tonani et al, 2008). The lateral boundary conditions are taken on a daily basis. Since December 2008 the tidal signal has been introduced in the model through the southern lateral open boundary conditions on barotropic velocities, as proposed by Flather in 1976.

In order to have the best estimate of the state of the sea for the production of a new forecast, the daily cycle of the system is combined once a week with a weekly cycle, necessary in order not to have a degeneration of the system.

A detailed description of the calibration and validation activities performed over this product can be found on the CMCC web portal (http://oceanlab.cmcc.it/afs).

The AFS dataset is provided to Torre Guaceto MPA as:

- monthly means: 01/2003 – 12/2017
- seasonal means: 01/2003 – 12/2017
- yearly means: 2003 -2017

2.2.1.2 ROSARIO96 - Malta Shelf Hydrodynamical Model

Sea Surface Temperature simulations were generated for the span of five years, from 2012 until 2016, at resolution of 1/96° (about 1 km). The numerical code used in the model is based on an application of the Princeton Ocean Model, POM (Blumberg and Mellor, 1987). ROSARIO96 runs with full atmospheric forcing and includes full thermohaline dynamics. POM is a primitive equation, stratified and non-linear numerical ocean model that utilizes the Boussinesq approximation and hydrostatic equilibrium. It uses the free surface, potential temperature and salinity, the three orthogonal components of velocity, the turbulence kinetic energy and the turbulence macro-scale as the prognostic variables. The model features a split mode time step and a sigma-coordinate transformation for the vertical grid. The bottom-following sigma layers allow the model to represent accurately regions of high topographic variability. The horizontal grid uses orthogonal coordinates and an 'Arakawa C' differencing scheme. The Mellor and Yamada (1982) turbulence closure scheme is used to calculate the coefficients of vertical mixing of momentum, the vertical eddy viscosity and the eddy diffusivity of heat and salt. Density is calculated by an adaptation of the UNESCO equation of state revised by Mellor (1991).

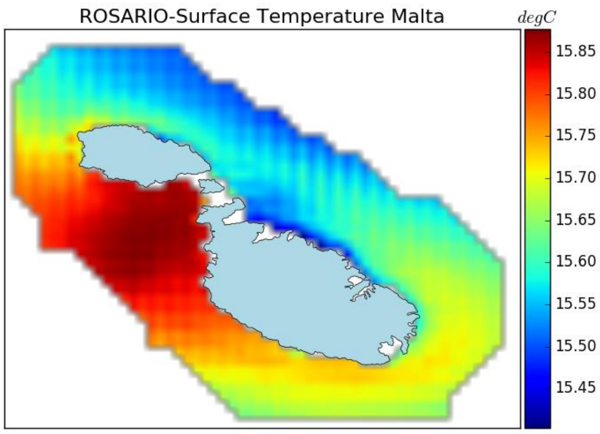

Figure 5 Sea surface temperature [degC] simulated by ROSARIO96 for Malta

The model is run over a domain from 13.80°E to 14.94°E in longitude, and from 35.42°N to 37.21°N in latitude, covering the full shelf area around the Maltese Islands. ROSARIO96 depends on a hierarchy of embedded models. It runs in one-way offline nested mode to a larger regional model covering the Central Mediterranean area (Sicilian Channel Regional Model, SCRM); the latter is nested to the basin scale Mediterranean Ocean General Circulation Model.

The shelf model has three open boundaries (on the east, south and west) and boundary conditions are provided through one-way nesting to the SCRM output for each forecast period. The nesting of temperature, salinity and velocities (total and barotropic) is necessary in order to transfer values of variables from the SCRM coarsely spaced grid to the finely spaced grid at the location of boundary region. The daily mean fields from the SCRM are interpolated in space over the higher resolution grid and in time at each model integration (3 sec). The grid points with missing data are filled by bilinear interpolation of the surrounding values. The shelf model is initialized using the temperature and salinity fields from the SCRM simulation and mapped into the model grid using a bilinear interpolation scheme.

The ROSARIO96 dataset is provided to North-East Maltese MPA as:

- monthly means: 01/2012 – 12/2016
- seasonal means: 01/2012 – 12/2016
- yearly means: 2012 -2016

2.2.2 Sea Surface Salinity

2.2.2.1 MFS, Mediterranean Forecasting System

Sea Surface Salinity data, simulated by MFS – Mediterranean Forecasting System, are provided by CMEMS (http://marine.copernicus.eu/) for whole Mediterranean Sea.

Two datasets have been considered for AMAre project:

a) MEDSEA_REANALYSIS_PHYS_006_004,
b) MEDSEA_ANALYSIS_FORECAST_PHY_006_013.

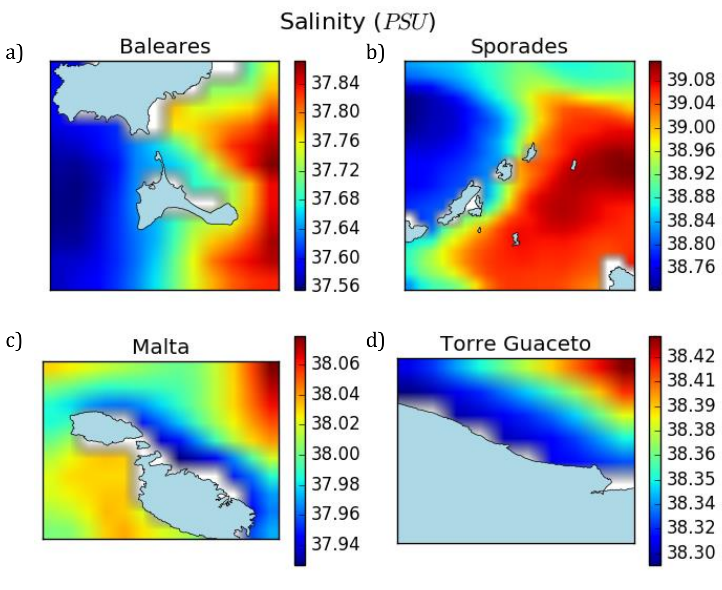

Figure 6 Sea surface salinity [psu] simulated by MFS for: a) Baleares, b) Sporades, c) Malta, d) Torre Guaceto.

Dataset *a)* covers January 1987 – December 2015 period. The Mediterranean Forecasting System, physical reanalysis component, is a hydrodynamic model, supplied by the Nucleous for European Modelling of the Ocean (NEMO), with a variational data assimilation scheme (OceanVAR) for temperature and salinity vertical profiles and satellite Sea Level Anomaly along track data. The model horizontal grid resolution is 1/16˚ (ca. 6-7 km) and the unevenly spaced vertical levels are 72 (Simoncelli et al., 2014).

Dataset *b)* covers January 2015 – nowadays period. The physical component of the Mediterranean Forecasting System (Med-Currents) is a hydrodynamic model implemented over the whole Mediterranean Basin. The model horizontal grid resolution is 1/24˚ (ca. 4 km) and has 141 unevenly spaced vertical levels. The hydrodynamics are supplied by the Nucleous for European Modelling of the Ocean (NEMO v3.6) and the model solutions are corrected by a variational data assimilation scheme (3DVAR) of temperature and salinity vertical profiles and along track satellite Sea Level Anomaly observations.

A detailed description of the calibration and validation activities performed over these products can be found on the CMEMS web portal.

The two datasets are provided to MPAs as:

- monthly means: 01/1987 – 12/2017
- seasonal means: 01/1987 – 12/2017
- yearly means: 1987 -2017

2.2.2.2 IBI, Iberian-Biscay-Irish Forecasting System

Sea Surface Salinity has been simulated for 2013-2017 years at high resolution (about 2.8km) for Baleares MPA with IBI, the Iberian-Biscay-Irish Forecasting System.

The dataset considered for AMAre project is called IBI_ANALYSIS_FORECAST_PHYS_005_001 and it is provided by CMEMS (http://marine.copernicus.eu/).

The operational IBI Ocean Analysis and Forecasting system, daily run by Puertos del Estado, provides a 5-day hydrodynamic forecast including high frequency processes of paramount importance to characterize regional scale marine processes (i.e. tidal forcing, surges and high frequency atmospheric forcing, fresh water river discharge, etc). A weekly update of IBI downscaled analysis is also delivered as historic IBI best estimates. The system is based on a (eddy-resolving) NEMO model application run at 1/36° horizontal resolution.

A detailed description of the calibration and validation activities performed over this product can be found on the CMEMS web portal.

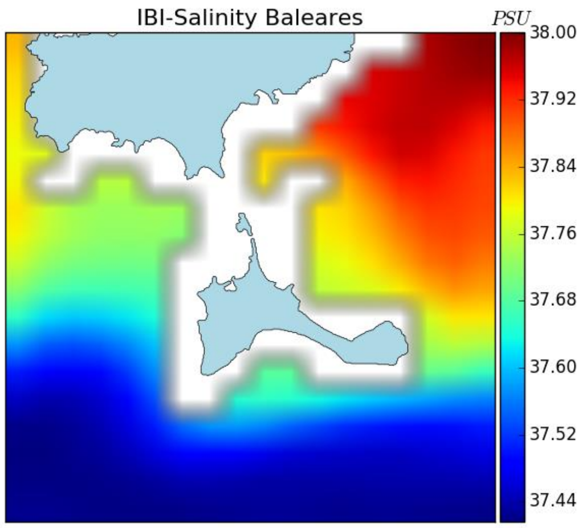

Figure 7 Sea surface salinity [psu] simulated by IBI for Baleares MPA

The dataset is provided to Baleares MPA as:

- monthly means: 01/2013 – 12/2017
- seasonal means: 01/2013 – 12/2017
- yearly means: 2013 -2017

2.2.2.3 AFS, Adriatic Forecasting System

Sea Surface Salinity has been simulated for a long time period, 2003-2017 years, at high resolution (about 2.2km) for Torre Guaceto MPA with AFS, the Adriatic Forecasting System.

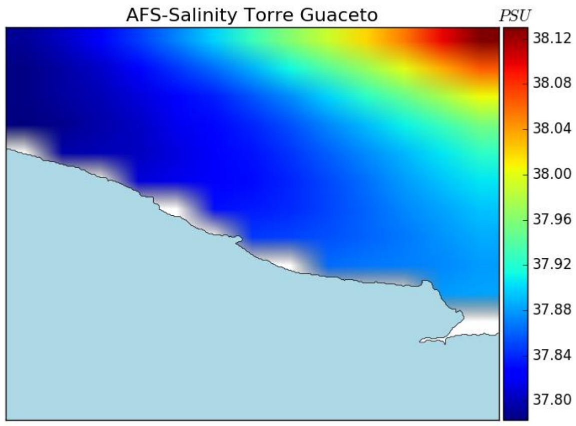

Figure 8 Sea surface salinity [psu] simulated by AFS forTorre Guaceto MPA

A detailed description of the calibration and validation activities performed over this product can be found in Section 2.2.1.1 of this document and on the CMCC web portal (http://oceanlab.cmcc.it/afs).

The AFS dataset is provided to Torre Guaceto MPA as:

- monthly means: 01/2003 – 12/2017
- seasonal means: 01/2003 – 12/2017
- yearly means: 2003 -2017

2.2.2.4 ROSARIO96 - Malta Shelf Hydrodynamical Model

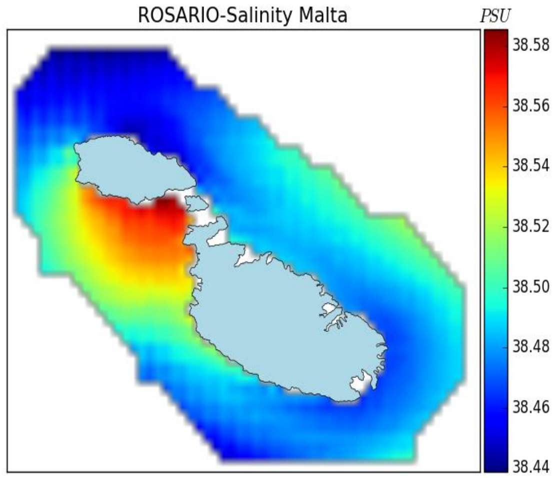

Figure 9 Sea surface salinity [psu] simulated by ROSARIO96 for Malta

Sea Surface Salinity simulations were generated for the span of five years, from 2012 until 2016, at resolution of 1/96° (approximately 1.16Km).

A more detailed description of the model can be found in Section 2.2.1.2 of this document and on the web portal managed by the Physical Oceanography Research Group (http://www.capemalta.net/MFSTEP/results0.html).

The ROSARIO96 dataset is provided to North-East Maltese MPA as:

- monthly means: 01/2012 – 12/2016
- seasonal means: 01/2012 – 12/2016
- yearly means: 2012 -2016

2.2.3 Sea Surface Currents

2.2.3.1 MFS, Mediterranean Forecasting System

Sea Surface Currents, simulated by MFS – Mediterranean Forecasting System, are provided by CMEMS (http://marine.copernicus.eu/) for whole Mediterranean Sea.

Two datasets have been considered for AMAre project:

a) MEDSEA_REANALYSIS_PHYS_006_004,
b) MEDSEA_ANALYSIS_FORECAST_PHY_006_013.

A detailed description of the calibration and validation activities performed over these products can be found in Section 2.2.2.1 of this document and on the CMEMS web portal.

The two datasets are provided to MPAs as:

- monthly means: 01/1987 – 12/2017
- seasonal means: 01/1987 – 12/2017
- yearly means: 1987 -2017

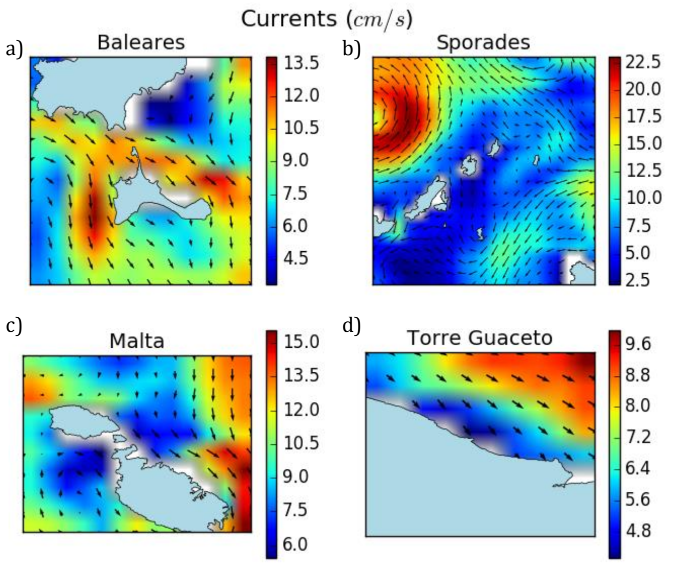

Figure 10 Sea surface currents [m/s] simulated by MFS for: a) Baleares, b) Sporades, c) Malta, d) Torre Guaceto

2.2.3.2 IBI, Iberian-Biscay-Irish Forecasting System

Sea Surface Currents have been simulated for 2013-2017 years at high resolution (about 2.8km) for Baleares MPA with IBI, the Iberian-Biscay-Irish Forecasting System.

The dataset considered for AMAre project is called IBI_ANALYSIS_FORECAST_PHYS_005_001 and it is provided by CMEMS (http://marine.copernicus.eu/).

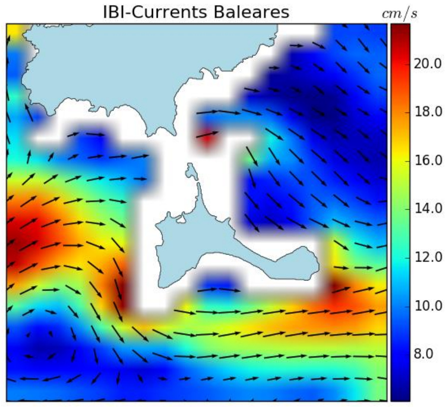

Figure 11 Sea surface currents [m/s] simulated by IBI for Baleares MPA

A detailed description of the calibration and validation activities performed over this product can be found in Section 2.2.2.2 of this document and on the CMEMS web portal.

The IBI dataset is provided to Baleares MPA as:

- monthly means: 01/2013 – 12/2017
- seasonal means: 01/2013 – 12/2017
- yearly means: 2013 -2017

2.2.3.3 AFS, Adriatic Forecasting System

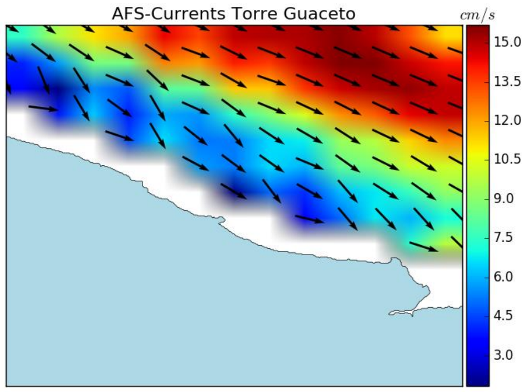

Figure 12 Sea surface currents [m/s] simulated by AFS for Torre Guaceto MPA

Sea Surface Currents have been simulated for a long time period, 2003-2017 years, at high resolution (about 2.2km) for Torre Guaceto MPA with AFS, the Adriatic Forecasting System.

A detailed description of the calibration and validation activities performed over this product can be found in Section 2.2.1.1 of this document and on the CMCC web portal (http://oceanlab.cmcc.it/afs).

The AFS dataset is provided to Torre Guaceto MPA as:

- monthly means: 01/2003 – 12/2017
- seasonal means: 01/2003 – 12/2017
- yearly means: 2003 -2017
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2.2.3.4 ROSARIO96 - Malta Shelf Hydrodynamical Model

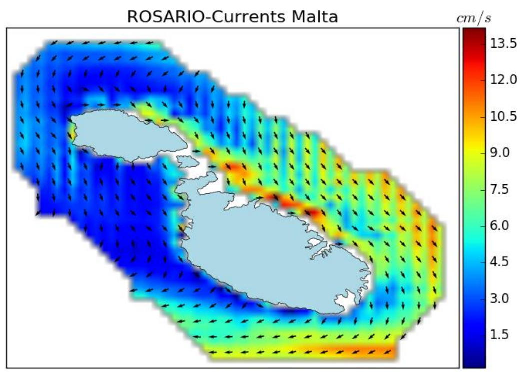

Figure 13 Sea surface currents [m/s] simulated by ROSARIO96 for Malta

Sea Surface Currents simulations were generated for the span of five years, from 2012 until 2016, at resolution of 1/96° (circa 1 km).

A more detailed description of the model can be found in Section 2.2.1.2 of this document and on the web portal managed by the Physical Oceanography Research Group (http://www.capemalta.net/MFSTEP/results0.html).

The sea surface currents datasets produced specifically for the area of the North-East MPA include:

- monthly means: 01/2012 – 12/2016
- seasonal means: 01/2012 – 12/2016
- yearly means: 2012 -2016

2.2.4 Nutrients

2.2.4.1 BFM, Biogeochemical Flux Model Forecasting System

The concentration of nutrients (phosphate and nitrate) at sea surface, simulated by BFM – Biogeochemical Flux Model Forecasting System, are provided by CMEMS (http://marine.copernicus.eu/) for whole Mediterranean Sea.

Two datasets have been considered for AMAre project:

a) MEDSEA_REANALYSIS_BIO_006_008,
b) MEDSEA_ANALYSIS_FORECAST_BIO_006_014.

Dataset *a)* covers January 1999 – December 2016 period. The reanalysis of Mediterranean Sea was carried using the OGSTM-BFM biogeochemical model and data assimilation of surface chlorophyll concentration with a resolution of 1/16 degree. OGSTM-BFM was driven by physical forcing fields produced as output by the Med-Currents model. The ESA-CCI database of surface chlorophyll concentration estimated by satellite and delivered within CMEMS-OCTAC was used for data assimilation. This reanalysis provides monthly means of 3D fields of chlorophyll, nutrients (phosphate and nitrate) and dissolved oxygen concentrations, net primary production, phytoplankton biomass, ocean pH and ocean pCO2.

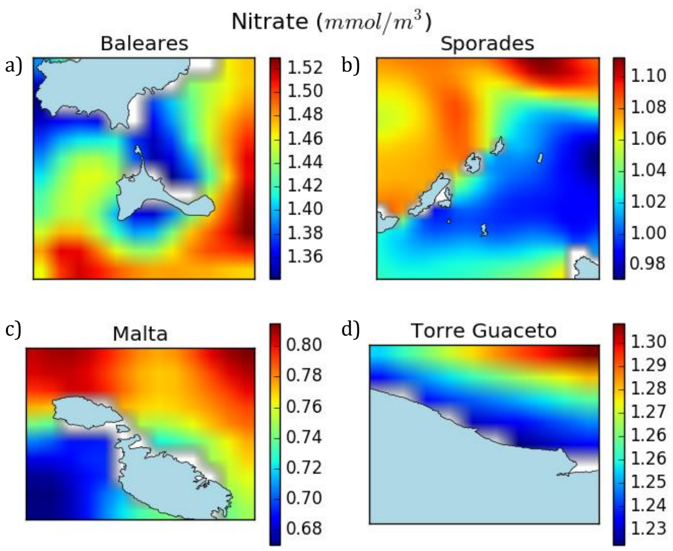

Figure 14 Sea surface concentration of nitrate [mmol/m^3] simulated by BFM for: a) Baleares, b) Sporades, c) Malta, d) Torre Guaceto.

Dataset *b)* covers January 2015 – nowadays period. The biogeochemical analysis and forecasts for the Mediterranean Sea at 1/24 degree are produced by means of the

MedBFM model system (i.e. the physical-biogeochemical OGSTM-BFM model coupled with the 3DVARBIO assimilation scheme). MedBFM model is run by OGS and uses as physical forcing the outputs of the Med-Currents products (managed by INGV). Seven days of analysis/hindcast and ten days of forecast are bi-weekly produced on Wednesday and on Saturday, with the assimilation of surface chlorophyll concentration from satellite observations (provided by the CMEMS-OCTAC).

A detailed description of the calibration and validation activities performed over these products can be found on the CMEMS web portal.

The two datasets are provided to MPAs as:

- monthly means: 01/1999 – 12/2017
- seasonal means: 01/1999 – 12/2017
- yearly means: 1999 -2017

2.2.5 Dissolved Oxygen

The concentration of dissolved oxygen at sea surface, simulated by BFM – Biogeochemical Flux Model Forecasting System, is provided by CMEMS (http://marine.copernicus.eu/) for whole Mediterranean Sea.

Two datasets have been considered for AMAre project:

a) MEDSEA_REANALYSIS_BIO_006_008,
b) MEDSEA_ANALYSIS_FORECAST_BIO_006_014.

A detailed description of the calibration and validation activities performed over these products can be found in Section 2.2.4.1 of this document and on the CMEMS web portal.

The two datasets are provided to MPAs as:

- monthly means: 01/1999 – 12/2017
- seasonal means: 01/1999 – 12/2017
- yearly means: 1999 -2017

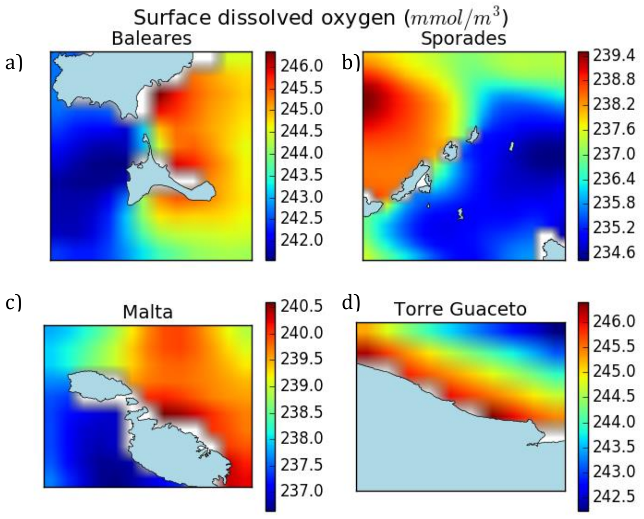

Figure 15 Sea surface concentration of dissolved oxygen [mmol/m^3] simulated by BFM for: a) Baleares, b) Sporades, c) Malta, d) Torre Guaceto.

3 Oceanographic indicators

3.1 Dissolved Oxygen at sea floor

The concentration of dissolved oxygen at sea floor, simulated by BFM – Biogeochemical Flux Model Forecasting System, is provided by CMEMS (http://marine.copernicus.eu/) for whole Mediterranean Sea.

Two datasets have been considered for AMAre project:

a) MEDSEA_REANALYSIS_BIO_006_008,
b) MEDSEA_ANALYSIS_FORECAST_BIO_006_014.

A detailed description of the calibration and validation activities performed over these products can be found in Section 2.2.4.1 of this document and on the CMEMS web portal.

The two datasets are provided to MPAs as:

- monthly means: 01/1999 – 12/2017
- seasonal means: 01/1999 – 12/2017
- yearly means: 1999 -2017

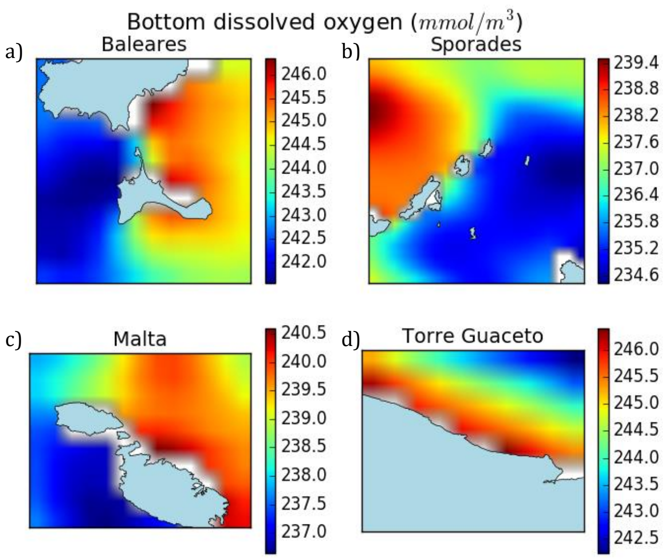

Figure 16 Concentration of dissolved oxygen at sea floor [mmol/m^3] simulated by BFM for: a) Baleares, b) Sporades, c) Malta, d) Torre Guaceto

This indicator is provided in order to highlight the oxygenation conditions at the bottom, so that indication of potential anoxic stress on the benthic ecosystem can be observed. In general the oxygenation condition near the bottom is modulated by the vertical stratification of the water column, so that lower, although not critical, oxygenation conditions might be expected during the summer season.

4 Oceanographic data access

4.1 FTP server

The oceanographic data described in this document are provided to AMAre partners via an ftp service available at the link ftp.oclab.cmcc.it/amare. The access is free of charge and password protected. An account can be requested sending an email to service.oclab@cmcc.it .

The data are in netCDF format and stored into different folders with nomenclature linked to the name of the provided variables:

- CHL/ for Chlorophyll-a concentration data retrieved by satellite,
- NUT/ for Nutrients concentration data simulated by BFM model,
- OXY/ for Dissolved Oxygen concentration data simulated by BFM model,
- OXYb/ for Dissolved Oxygen concentration data at sea floor simulated by BFM model,
- SSC/ for Sea Surface Currents data simulated by MFS, AFS, ROSARIO96 and IBI models,
- SSS/ for Sea Surface Salinity data simulated by MFS, AFS, ROSARIO96 and IBI models,
- SST/ for Sea Surface Temperature data simulated by AFS and ROSARIO96 models and retrieved by satellite,
- TRA/ for water transparency data retrieved by satellite.

File nomenclature is self-describing:

${var}_${MPA}_${source}_${temporal frequency}_${spatial resolution}_${start time}_${end time}.nc

where

- ${var} identifies the variable stored into the file (e.g. CHL, NUT, OXY,SSC,…),
- ${MPA} is the two-characters acronym for the MPA of reference (e.g. BA for Baleares, MA for Malta, SP for Sporades and TG for Torre Guaceto),
- ${source} identifies the source of the data (e.g. sat for satellite, AFS for Adriatic Forecasting System, …),
- ${temporal frequency} reports the temporal frequency of the time series (e.g. mm for monthly means, sm for seasonal means, ym for yearly means),
- ${spatial resolution} describes the spatial resolution of the data (e.g. 1km, 2km, ...),
- ${start time} reports the start time of the time series in YYYYMM format,
- ${end time} reports the end time of the time series in YYYYMM format.

<u>Example</u>

SST_TG_AFS_sm_2km_200301_201712.nc

The file provides the Sea Surface Temperature simulated by AFS model for Torre Guaceto MPA with a temporal frequency of seasonal means and spatial resolution of 2km. The time series covers the period 200301 – 201712.

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