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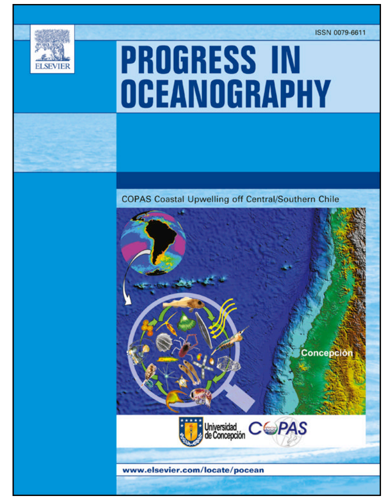

OCLE: A EUROPEAN OPEN ACCESS DATABASE ON CLIMATE CHANGE EFFECTS ON LITTORAL AND OCEANIC ECOSYSTEMS

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OCLE: A EUROPEAN OPEN ACCESS DATABASE ON CLIMATE CHANGE EFFECTS ON LITTORAL AND OCEANIC ECOSYSTEMS

1. Introduction

Studies on historical and future distribution of marine species are frequently limited by the lack of relevant data on abiotic components (IPCC, 2014), especially when working over large areas (Robinson et al., 2017). Important advances have been achieved in the last years regarding availability of global information on physical and chemical driven forces affecting species distributions. WorldClim (Hijmans et al., 2005) marked a milestone in terrestrial species distribution studies, as it opened the opportunity to address global research studies with high resolution. Other databases including historical and projected variables in the terrestrial environment, mainly temperature and precipitation, such as Climond (Kriticos et al., 2012), Climate wizard (Girvetz et al., 2009) or Chelsea (Karger et al., 2016) have emerged recently. However, in the marine environment the number of global databases is limited. Bio-Oracle is the most valuable reference because it provides surface and benthic layers for water temperature, salinity, nutrients, chlorophyll, sea ice, current velocity, phytoplankton, primary productivity, iron and light at high resolution and global coverage (Assis et al., 2017; Tyberghein et al., 2012). Other remarkable databases are MARSPEC (Sbrocco and Barber, 2013), offering variables derived from bathymetry, slope, salinity and sea surface temperature, Aquamaps (Ready et al., 2010), focused on marine animals, or Hexacoral (Fautin and Buddemeier, 2002), with the aim to understand spatial and temporal patterns in biogeochemistry and biogeography. Some databases cover both land and sea areas, such as the MERRAclim (Vega et al., 2017), which offers decadal data of 19 derived variables of air temperature and humidity atmospheric water vapour.

Despite the important contributions of these marine databases, different important questions still require further developments. The first issue to be considered is the common absence of data on hydrodynamic variables (e.g. wave height, current speed or bottom and wind stress) with global coverage, although there is considerable evidence of their relevance in species distribution (Callaghan et al., 2015; de la Hoz et al., 2018; Ramos et al., 2014). Among these, the bottom shear stress is very important when studying benthic vegetation because its influence on their settlement and survival (Pace et al., 2017), but this kind of information does not seem to be currently available for large areas. A second concern refers to the lack of homogeneity in the time intervals used to calculate different parameters and consequent limitations for long-term multi-criteria retrospective analysis. The third issue that rises in this analysis applies to the ecological reliability of the selected parameters. Most databases only provide mean, minimum and maximum values for long periods, although many environmental triggers influencing life cycles and species distributions seem to act on extreme events occurring at shorter time scales (Galván et al., 2016; Seabra et al., 2015), especially in a climate change context (Lima and Wethey, 2012). Therefore, the formulation of biologically-meaningful parameters using datasets and increasing time resolutions arises as two key steps in order to get more realistic results. Moreover, when defining parameters for projected futures, it is essential to work with the best information available, as the General Circulation Models (GCMs), that take into account the Representative Concentration Pathways (RCPs) introduced in the 5th Assessment Report of the Intergovernmental Panel on Climate Change (IPCC, 2014).

Accordingly, the improvement of the available databases must address those gaps in order to adapt them to current and future needs for species distribution studies. Homogeneous and complete high resolution data, integrated at different time scales, ecological-sounded parameters, based on abiotic conditions that determine the ecology of the species of interest have to be included. Additionally, raw data have to be controlled and homogenised to guarantee the quality of the derived products. Concerning temporal periods, different resolutions should be available to allow researchers to define specific parameters for each species. Besides, data should fit to the spatial scale of the work, covering the study area with the necessary detail.

Finally, the access to the data have to be free and very intuitive for users, reducing to the maximum the weight and the computing resources used for getting the information.

Trying to comply with these requirements and using the best data available, to our best knowledge, this study presents the open access database on climate change effects on littoral and oceanic ecosystems (OCLE), an ecological-driven database of present and future hazards for marine life in Europe. As a first step the database is oriented toward seagrasses and algae, due to their key role in the food chain of marine ecosystems, contributing to the maintenance of biodiversity and providing ecosystem services (Duarte et al., 2013; Mazarrasa et al., 2017; Ondiviela et al., 2014). However, the aim of OCLE is to provide researchers with open access accurate information for marine studies, not only for coastal studies, but also in oceanic waters.

2. Material and methods

2.1. Study area

All the regional European seas have been included in OCLE, at two different resolutions: 0.1º for coastal waters (until 50 m depth), to better characterize the potential habitat of coastal ecosystems; and, 0.5º for oceanic waters. That way, the OCLE database can provide information for a total of 18200 points considered as "virtual sensors", of which 12074 correspond to coastal areas and 6126 to offshore areas (Fig. 1).

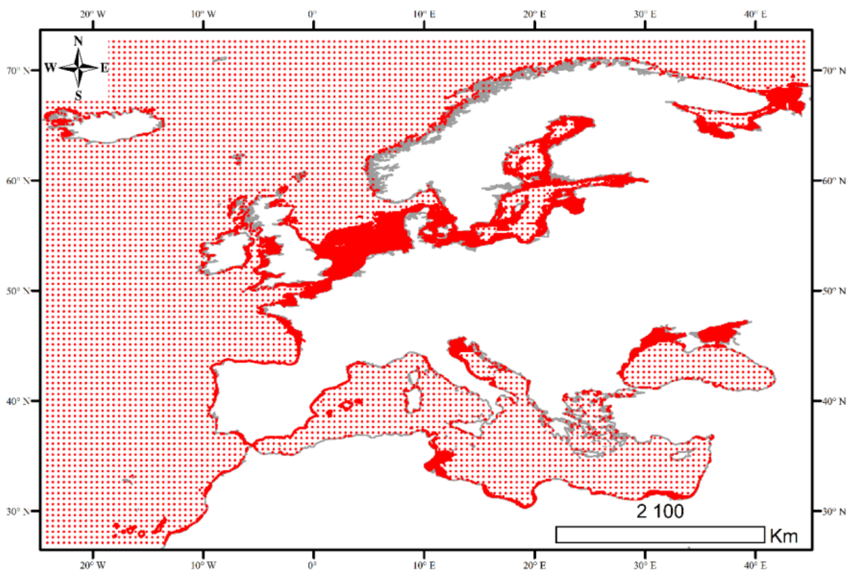

Fig. 1. Representation of the “virtual sensors” integrated in the OCLE database.

2.2. Variables and parameters

The variables included in OCLE were first selected because of their functional relationship with seagrasses and macroalgae distributions. Those variables with a heterogeneous distribution in space and/or time were discarded. General meteo-oceanographic variables (hereinafter referred to as met-ocean variables) were considered first, including different physical and chemical factors, such as temperature (Fralick et al., 1990; Valle et al., 2014), light (Best et al., 2001; Larkum et al., 2006), salinity (Nejrup and Pedersen, 2008; Touchette, 2007) or nutrients (Hughes et al., 2004; Martínez et al., 2012b). Those were complemented with other variables related to the stressful conditions that limit intertidal organisms distributions, such as desiccation, a decisive survival factor characterized by the tidal range (Pearson et al., 2009), the wind speed (Lipkin et al., 1993), the significant wave height (Jones et al., 2015) and sea level (Short and Neckles, 1999), especially under future scenarios. A final group of variables regarding exposure of subtidal species to uprooting conditions was also taken into account. Stress to high energy conditions is characterized by the bottom orbital speed (Young et al., 2015), the currents speed (Infantes et al., 2011) and the, significantly more complex variable, bottom shear stress (Pace et al., 2017).

For each variable, a complete set of parameters was selected in order to reflect in a more holistic perspective the state of the environment, as a proxy of ecological processes. For historical data, the maximum, minimum, mean, standard deviation, range and percentiles 10, 25, 50, 75 and 90 were calculated at each virtual sensor, for seasonal, monthly, yearly, five-yearly and full (1985-2015) periods (Fig. 2). Besides, according to the more detailed information available and their close relationship to macrophytes distributions, some specific and relevant parameters to detect changes in extreme conditions of sea and air temperatures (i.e. number of consecutive days over the percentile 90, (Torresan et al., 2016), and for the shear stress (i.e. number of days over 2.2 Nt/m^2: (Vousdoukas et al., 2012) were calculated (Fig. 2). Furthermore, for future projections, the same group of parameters were calculated on a seasonal, yearly and full period, considering both the near-term (2040-2069) and the long term (2070-2099) for two RCPs, namely RCP 4.5 and RCP 8.5.

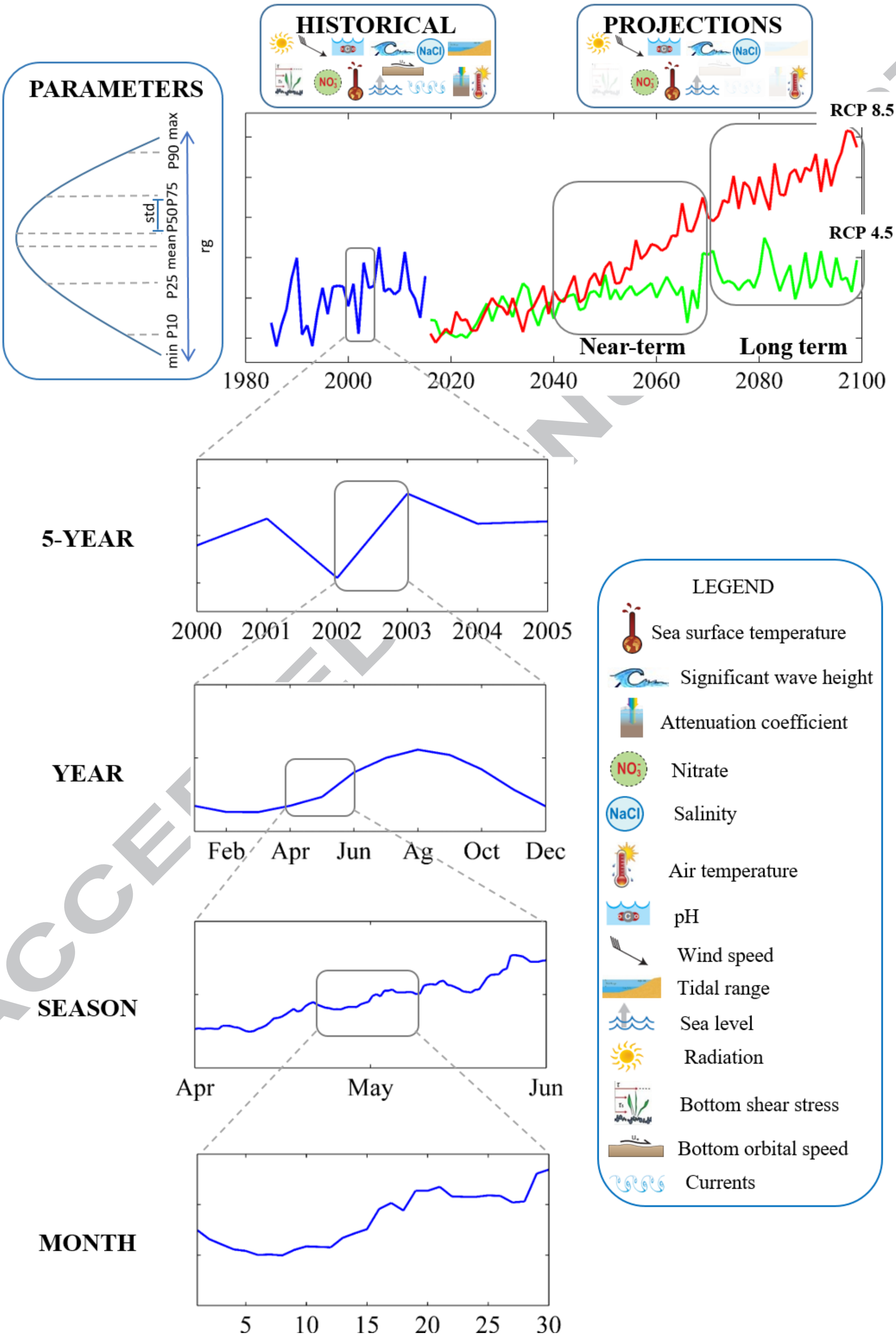

Fig. 2. Parameters calculated and their temporal resolution. Max, maximum; min, minimum; P, percentile; std, standard deviation; rg, range.

2.3. Data sources and methods

Historical data were compiled from satellite (Schuckmann et al., 2016), reanalysis (Cid et al., 2014; Donlon et al., 2012; Perez et al., 2017; Reguero et al., 2012; Saha et al., 2010; Stark et al., 2007) or *in situ* measurements (Weatherall et all., 2015).

A quality control was established along all steps. First, only validated sources were selected, either with instrumental data (Garnesson et al., 2016; Perruche et al., 2015; Saha et al., 2014, 2010; Schuckmann et al., 2016), remotely sensed information (Donlon et al., 2012) or both of them (Cid et al., 2014; Perez et al., 2017). To get a temporal and spatially homogeneous database, only sources with time series longer than 15 years and a spatial resolution lower than 0.5º were taken into account. Final selected data were compared with existing studies (e.g. Rhein et al., 2013; Collins et al., 2013; EEA, 2009).

For future projections data from the fifth phase of the Coupled Model Intercomparison Project (CMIP5, Taylor et al., 2012) were used. CMIP5 provides results of a set of coordinated climatic model experiments using GCMs at two times scales, a near-term (2040-2069) and a long-term period (2070-2099) for different RCPs. This experimental set has been selected for its high skill to represent projections at the North-East Atlantic Region (Perez et al., 2014) and because it is the reference set provided by the IPCC for climate research and impact and risk assessment. Quality assurance and control procedures for projected data were based on mean squared errors (MSE) between the historical data series selected and those of the GCMs for the reference period (1985-2005). This analysis was carried out for each of the Marine Strategy Framework Directive region (European Commission, 2008) to avoid a bias by local processes. Outliers (GCMs with more than 20% of their values out of the limits within the $MSE_{mean} \pm MSE_{std}$) were discarded (Chai and Draxler, 2014). More detailed information is available in Appendix A.

The final data sources are shown in Table 1. Historical and projected periods are shown for each variable and final GCMs selected are named. More detailed information about original data sources and GCMs is available in Appendix B.

Table 1. Variables selected with indication of periods, sources and the applied method to data gathering. For projections, the GCMs used are specified.

VARIABLE	Period	Method	Source
Sea Surface Temperature (SST) (ºC)	1/1/1985 – 31/12/2015	Reanalysis	OSTIA dataset (NASA)
	1/1/2010 – 31/12/2099	Projections CNRM-CM5, GFDL-ESM2G, IPSL-CM5A-LR, IPSL-CM5A-MR, MPI-ESM-LR, MPI-ESM-MR	CMIP5
Significant wave height (Hs) (m)	1/1/1985 – 31/12/2015	Reanalysis	GOW (IH Cantabria)
	1/1/2010 – 31/12/2099	Projections GFDL-ESM2G, GFDL-ESM2M, IPSL-CM5A-LR, MPI-ESM-LR, MPI-ESM-MR	CMIP5
Bathymetry (m)	-	Satellite and *in situ* measurements	GEBCO 2014 (BODC).
Light attenuation coefficient (Kd) (m^{-1})	25/1/1998–27/12/2015	Satellite measurements	Copernicus Marine System (ESA)
Substrate	-	Renalysis and *in situ* measurements	EMODNET EUSeaMap
Nitrate (mol/m^3)	16/1/1998–16/12/2014	Reanalysis	Copernicus Marine System (ESA)
	15/1/2010–15/12/2099	Projections IPSL-CM5A-LR, IPSL-CM5A-MR, IPSL-CM5B-LR, MPI-ESM-LR, MPI-ESM-MR	CMIP5
Salinity (psu)	1/1/1985 – 31/12/2015	Reanalysis	CFSR
	15/1/2010–15/12/2099	Projections IPSL-CM5A-LR, IPSL-CM5A-MR, IPSL-CM5B-LR	CMIP5
Air Temperature (ºC)	1/1/1985 – 31/12/2015	Reanalysis	CFSR
	1/1/2010 – 31/12/2099	Projections CNRM-CM5, GFDL-ESM2G, GFDL-ESM2M, IPSL-CM5A-LR, IPSL-CM5A-MR, MPI-ESM-LR, MPI-ESM-MR	CMIP5
pH	13/1/1985 – 8/11/2005	Reanalysis	CMIP5
	16/1/2010–16/12/2099	Projections IPSL-CM5A-LR, IPSL-CM5A-MR, IPSL-CM5B-LR, MPI-ESM-LR	CMIP5
Wind speed (m/s)	1/1/1985 – 31/12/2015	Reanalysis	CFSR
	1/1/2010 – 31/12/2099	Projections CNRM-CM5, GFDL-ESM2G, GFDL-ESM2M, IPSL-CM5A-LR, IPSL-CM5A-MR, MPI-ESM-MR	CMIP5

Tidal range (m)	1/1/1985 – 31/12/2013	Reanalysis	GOST (IH Cantabria)
Sea level rise (m)	-	-	-
	1/1/2010 – 31/12/2099	Projections (IPCC 2014)	(Slangen et al., 2014)
Radiation (W/m^2)	1/1/1985 – 31/12/2005	Projections GFDL-ESM2G, IPSL-CM5A-LR, IPSL-CM5A-MR, IPSL-CM5B-LR, MPI-ESM-LR, MPI-ESM-MR	CMIP5
	1/1/2010 – 31/12/2099	Projections GFDL-ESM2G, IPSL-CM5A-LR, IPSL-CM5A-MR, IPSL-CM5B-LR, MPI-ESM-LR, MPI-ESM-MR	CMIP5
Bottom shear stress (N/m^2)	1/1/1985 – 31/12/2013	Reanalysis	Own development
Bottom orbital speed (m/s)	1/1/1985 – 31/12/2013	Reanalysis	GOW (IH Cantabria)
Currents (m/s)	1/1/1985 – 31/12/2013	Reanalysis	GOST (IH Cantabria)

OSTIA, Operational Sea surface Temperature and sea-Ice concentration Analysis; NASA, National Aeronautics and Space Administration; CMIP5, World Climate Research Programme; GOW, Global Ocean Wave; GEBCO, General Bathymetric Chart of the Oceans; BODC, British Oceanographic Data Centre; ESA, European Space Agency; CFSR, NCEP Climate Forecast System Reanalysis; GOST, Global Ocean Surges Tides. All databases are at a spatial resolution of 0.1º and 0.5º, according to the defined mesh (Fig. 1).

For each variable, data available from the original sources closest to the defined virtual sensors were selected. Bottom shear stress calculations were based on hourly waves and currents data, obtained from GOW (Perez et al., 2017) and GOST (Cid et al., 2014) databases (Table 1), applying the formulation of Soulsby (Soulsby, 1997). The bed roughness was derived from the substrate type, according to Soulsby (1983). This formulation was selected because it has demonstrated good results in other studies (Roulund et al., 2016; Tomás et al., 2012). All variables were temporally homogenised through the compilation of raw to daily, when possible, or monthly data. For projections, parameters were calculated for each GCM, RCP and period, and averaged with the ensemble method (Arnell et al., 2014). For sea level projections, the IPCC values were considered (Slangen et al., 2014). Analyses were conducted using Climate Data Operators (CDO 1.7), NetCDF Operators (NCO 4.4.5), Matlab 8.1 and ArcGis 10.1.

3. Results and discussion

3.1. OCLE data

According to the aforementioned detected gaps, OCLE represents a step further in the capacity to characterize marine and coastal systems from an integrated temporal and spatial perspective. OCLE provides homogeneous and open access accurate information of 16 variables and 12 derived parameters for historical and projected periods, which completes the existing databases. Facing requirements for making predictions based on retrospective analysis of species distributions at different scales, this work has considered four fundamental aspects: i) hydrodynamic characterization, ii) spatial and temporal dimensions, iii) biologically-meaningful parameters and iv) reliable climate change projections.

i) Hydrodynamic characterization

This is a key aspect because this type of variables are usually omitted in other databases, despite their ecological importance for sessile species (Callaghan et al., 2015; de la Hoz et al., 2018; Pace et al., 2017; Ramos et al., 2016b). Furthermore, their temporal and spatial variability along the European seas constitutes a critical element to be considered for a holistic physical characterization. Consequently, it is essential to include variables that allow a complementary interpretation of the physical resistance of species, such as waves, currents and bottom orbital speed, both included in OCLE (Fig 3).

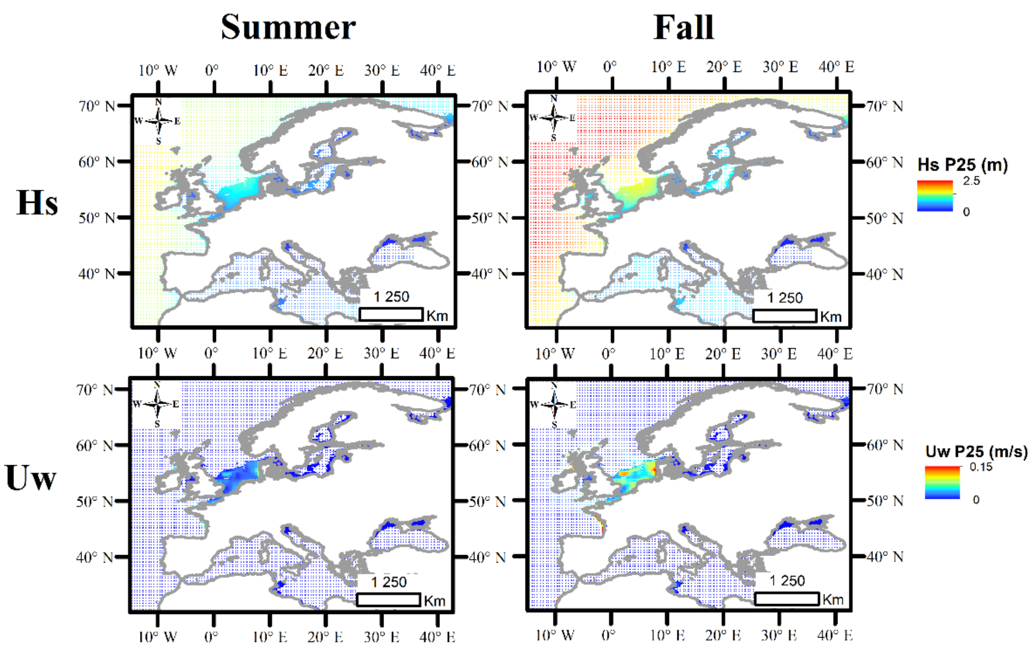

Fig. 3. Percentile 25 of significant wave height (Hs, upper panel) and currents (Uw, bottom panel), for summer (left) and fall (right) seasons.

One important contribution of OCLE is the development of a derived variable, the bottom shear stress, which allows detecting the areas where the energy of the system is higher and, consequently, the stress for benthic organisms (Pace et al., 2017). Although regional studies of bottom shear stress have been carried out by other authors (Alekseenko et al., 2017; Dalyander et al., 2013; Tomás et al., 2012), a broad scale characterization along Europe has not been developed so far. This gap has been solved in OCLE providing average and extreme parameters of bottom shear stress. The historical distribution of the winter 90th percentile reflects the spatial differences when considering potential bottom shear stress impacts on marine flora (Fig 4), as previously demonstrated in the North Sea, the west coasts of Ireland or the Gulf of Gabès (Ben Brahim et al., 2015; Kregting et al., 2016; Schanz and Asmus, 2003).

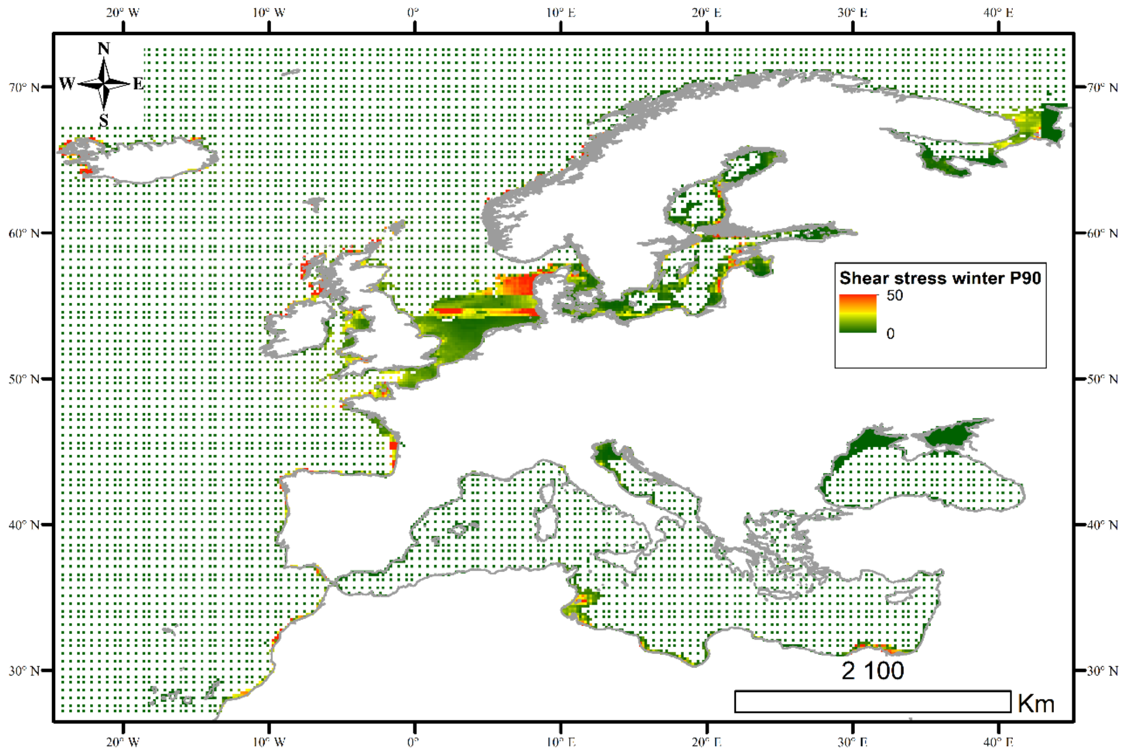

Fig. 4. Shear stress percentile 90 average values of all winters of the historic period (N/m^2).

ii) Spatial and temporal dimensions

One of the first requirements in the design of an end-users oriented database is the integration of their needs. Most databases available provide a unique value for the whole period considered, which largely limits the type of hypothesis posed concerning prospective and retrospective trend analysis on species distribution (Thurstan et al., 2015). OCLE offers data with a higher resolution from daily or monthly to full period considered (Fig. 2). This allows detecting not only average environmental conditions, but also extreme conditions, which affect many species responses (Galván et al., 2016).

The interannual variability results crucial because species can respond to yearly episodes, most of them lost when using long-term averaged values. Similarly, intra-annual variability provides a huge potential for testing research questions regarding ecological responses of marine species versus historical and projected patterns in the abiotic environment linked to different natural or anthropogenic scenarios. For instance, seasonal differences in the potential influence of river

(Spillman et al., 2007) or the industrial activity on nitrate discharges (Burson et al., 2016) may be estimated from Fig. 5 at the European scale.

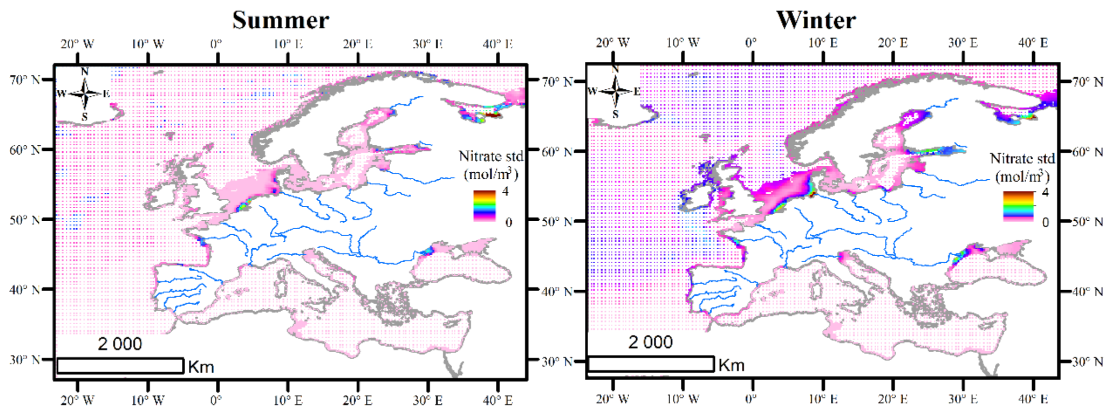

Fig. 5. Nitrate standard deviation of the year 2000 in summer (left) and winter (right). In blue, main European rivers.

Two spatial resolutions are available in OCLE in order to adapt the analysis scale and computing resources to the end-users needs. This allows addressing from general trend studies, at a spatial resolution of 0.5º (e.g. Fig 3) to detailed studies, at 0.1º resolution (Fig. 6). In general terms, this dual approach will facilitate more precise studies at the coastal zone, where the influence on macrophytes-based communities occur; whereas, a balance between a lower spatial resolution and a much more detailed abiotic information compared to previous works is available for oceanic areas. At the same time, OCLE opens the possibility for very specific studies by downscaling the variables at even higher resolutions (Galván et al., 2016; Tomás et al., 2016).

Finally, an important issue to ensure the potential applications of the database is the temporal and spatial homogeneity among variables. Some existing databases combine variables with diverse periods, due to the difficulty to collect temporal homogeneous data. However, a huge effort has been developed in this work to provide temporally homogeneous information for all variables (within the period 1985-2015), allowing the comparison among them (Table 1).

iii) Biologically-meaningful parameters

Abiotic conditions that control the settlement, survival and reproduction of marine species are key factors that may determine, together with biological interactions, the species distribution (Araújo and Guisan, 2006). Currently, studies on specific thresholds for different physical and chemical variables affecting functional processes of macrophytes are mostly addressed in laboratory or *in situ* experiments. Their application to field conditions and under usually more complex environments may limit their transferability (Valiela, 2001). Variables and parameters established in OCLE have been selected to cover some ecological processes mainly related to the macroalgae and seagrasses distributions, for both average and extreme abiotic conditions. The later ones are crucial for the survival of those species which are living in their limits of distribution (Araújo et al., 2016). In spite of the important advantages of OCLE, the involvement of the scientific community in the development of more specific parameters (Bosch et al., 2017) and the definition of other variables related to species distributions at different scales is necessary (Martínez et al., 2012a; Ramos et al., 2016a). For example, according to the threshold for bottom shear stress proposed by Vousdoukas et al. (2012), an analysis regarding the distribution of macrophytic communities through time (1985-2014) in response to the estimated increase in the stress in the intertidal zones is carried out along the coasts of Denmark. (Fig 6),

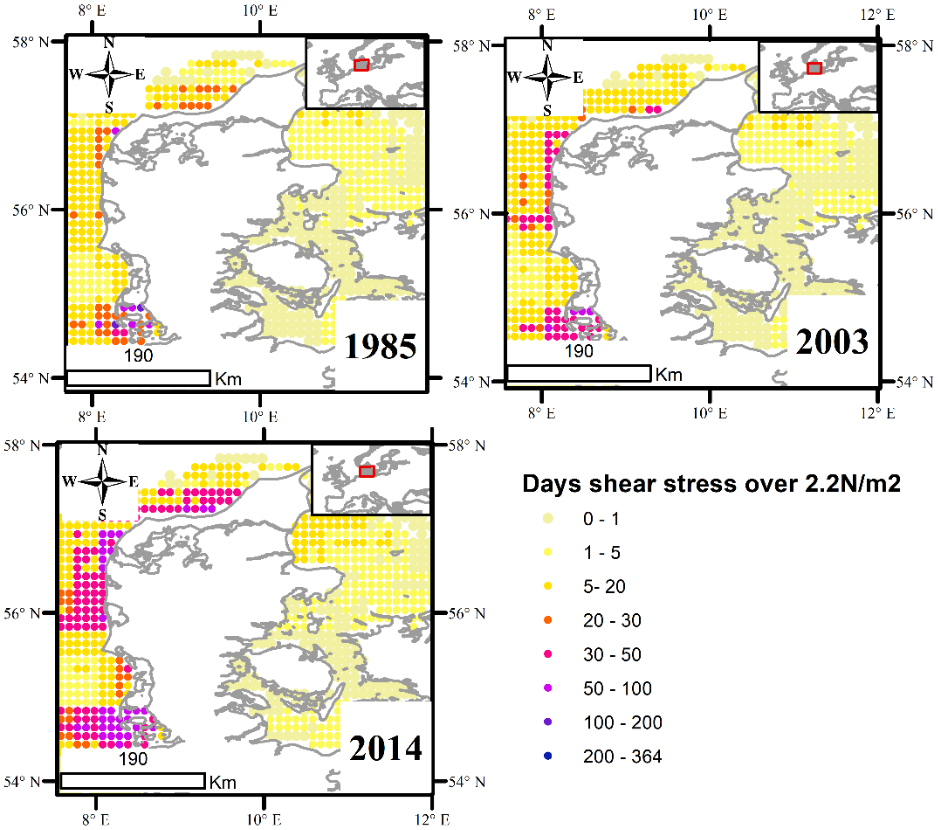

Fig. 6. Number of consecutive days in each year (1985 (top left), 2003 (top right) and 2014 (bottom left)) with bottom shear stress values over 2.2 N/m^2.

To arise the definition of these thresholds, the availability of a broad set of spatial and temporal information on biological-sounded parameters at the right scale is crucial. This information can be used in species distribution models (SDMs) for the statistical determination of limiting factors and the establishment of parameters response curves. This approach may be used as a proxy to understand the present and predict future distributions.

iv) Reliable climate change projections

Concerning projections, OCLE does include, to our knowledge, the best information available (IPCC, 2014). Two future scenarios (RCP 4.5, RCP 8.5) were considered for the near (2040-2069) and long term (2070-2099), for eight of the variables (Table 1). Besides, the bias of the

GCMs has been reduced thanks of the ensemble technique that has been applied in the quality control process (Camus et al., 2017; Meier et al., 2011) (Fig 7).

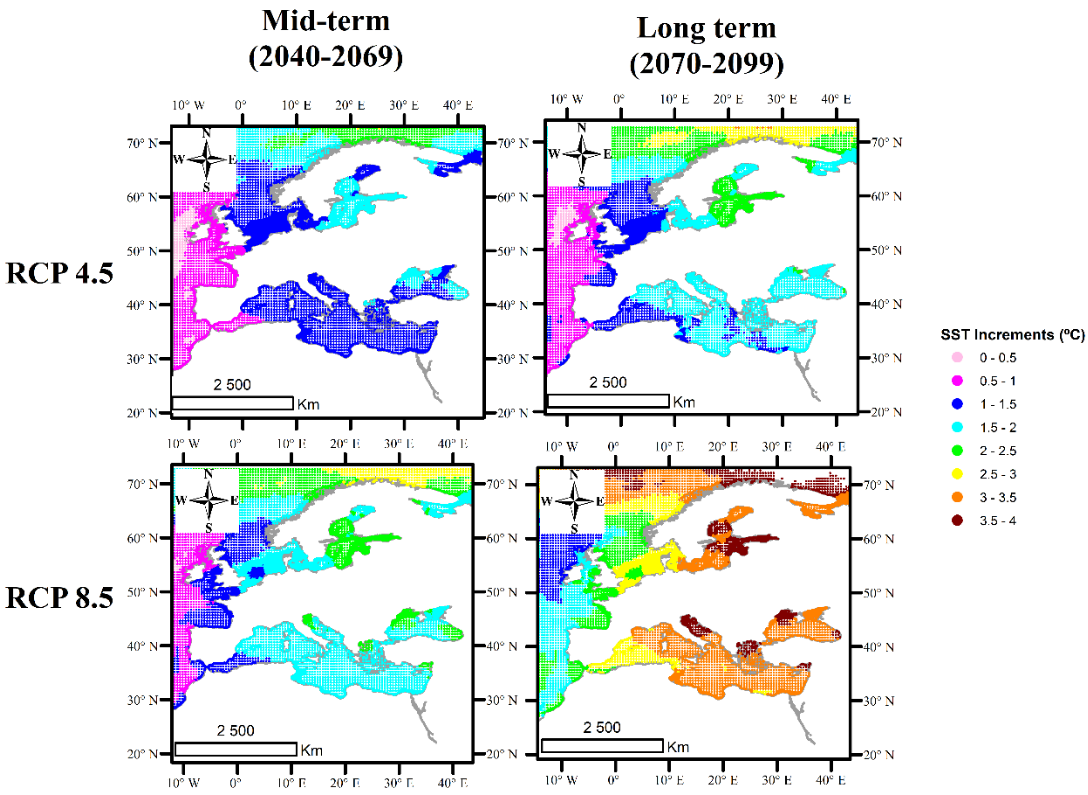

Fig. 7. SST increase with respect to the reference period for the RCP 4.5 (upper panel) and RCP 8.5 (lower panel) for the near-term (left) and long term (right).

3.2. OCLE website

OCLE results are available for free and stepwise download at http://ocle.ihcantabria.com, to allow users' choice of the most appropriate data for their research needs, regarding the period (historical or projected), the variables (16 options) and parameters of interest (12 choices). The full historical record (1985-2015) is split into five-yearly datasets.

Concerning projections, data for the near-term (2040-2069) and the long term (2070-2099) are available for each RCP considered. Researchers can select the datasets of interest and explore the data on a map or downloading the information in a .csv format to be used in SDMs or to be visualized in geographic information systems. To avoid computational overcharges, OCLE allows the spatial filtering, by zone selection over the map, coordinates screening, coastal areas (until 50 m depth) or predefined regions according to the European Commission (2008). Additionally, it is possible to access to yearly data and customized parameters on request through the website. This opens up the possibility to a broad field of work generating more specific parameters.

4. Conclusions

The OCLE ecologically-driven database provides open access accurate abiotic information for research studies in European seas, complementing existing ones and addressing several gaps. Data are available at two spatial scales (0.1º and 0.5º) for long time series (1985-2015 and 2040-2099), which allows the definition of precise parameters to evaluate key factors affecting species distribution, such as the own developed variable bottom shear stress. The output format (.csv) can be used in diverse kinds of marine studies, with different purposes and scales, such as species distribution modelling or the physical and ecological classification of large areas (Calleja et al., 2017; de la Hoz et al., 2018; Ramos et al., 2012; Rueda et al., 2017).

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Velarde for their valuable help in bottom shear stress calculation, sources selection, GCMs treatment, remote sensing advice and website development, respectively.

DATA ACCESSSIBILITY

The OCLE information is accessible online at http://ocle.ihcantabria.com for download (as csv files) and preview.

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APPENDICES

Details of electronic appendices are provided below:

Appendix A. Mean squared error (MSE) graphics.

Appendix B. General Circulation Models (GCMs) information.

APPENDIX A. Mean squared error (MSE) graphics

NITRATE

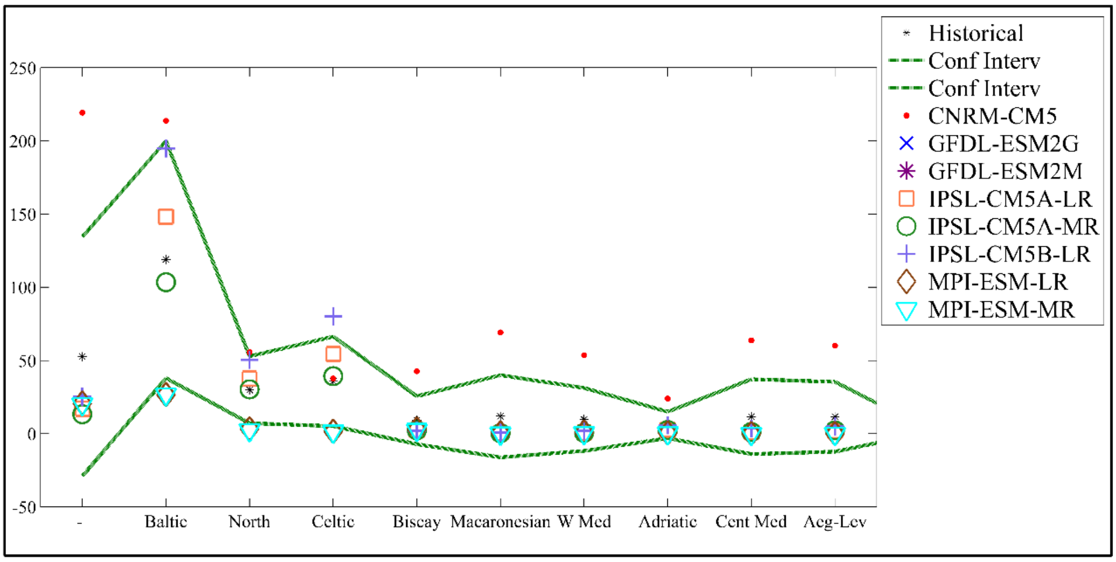

Fig. A.1 Mean squared error of General Circulation Models (represented according to legend) for nitrate values in each Marine Strategy Framework region. Black asterisk represents the historical values obtained from sources in Table 1 and green lines their confidence intervals.

SALINITY

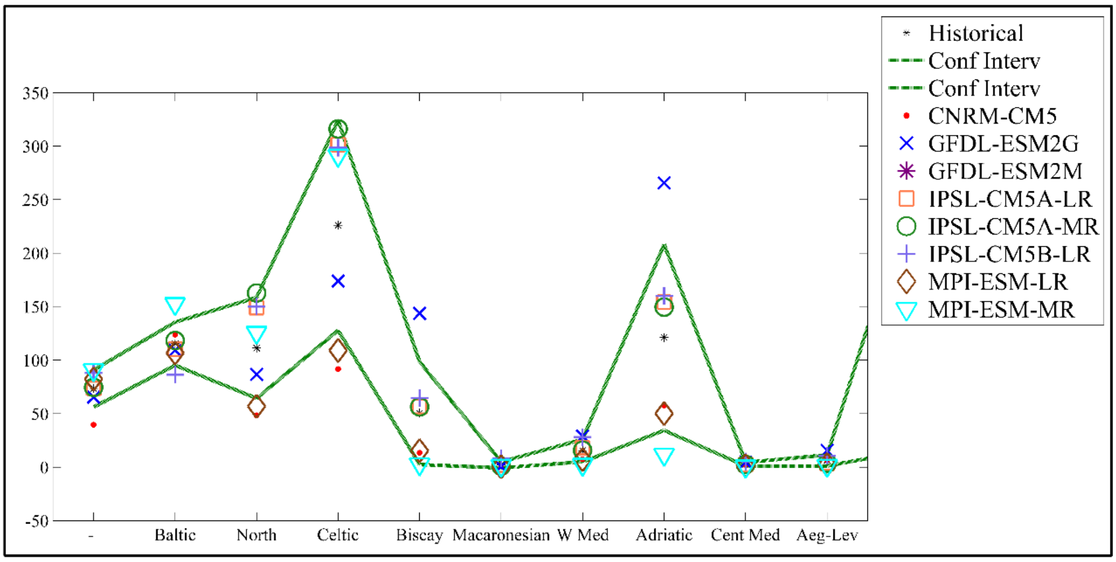

Fig. A.2 Mean squared error of General Circulation Models (represented according to legend) for salinity values in each Marine Strategy Framework region. Black asterisk represents the historical values obtained from sources in Table 1 and green lines their confidence intervals.

SEA SURFACE TEMPERATURE

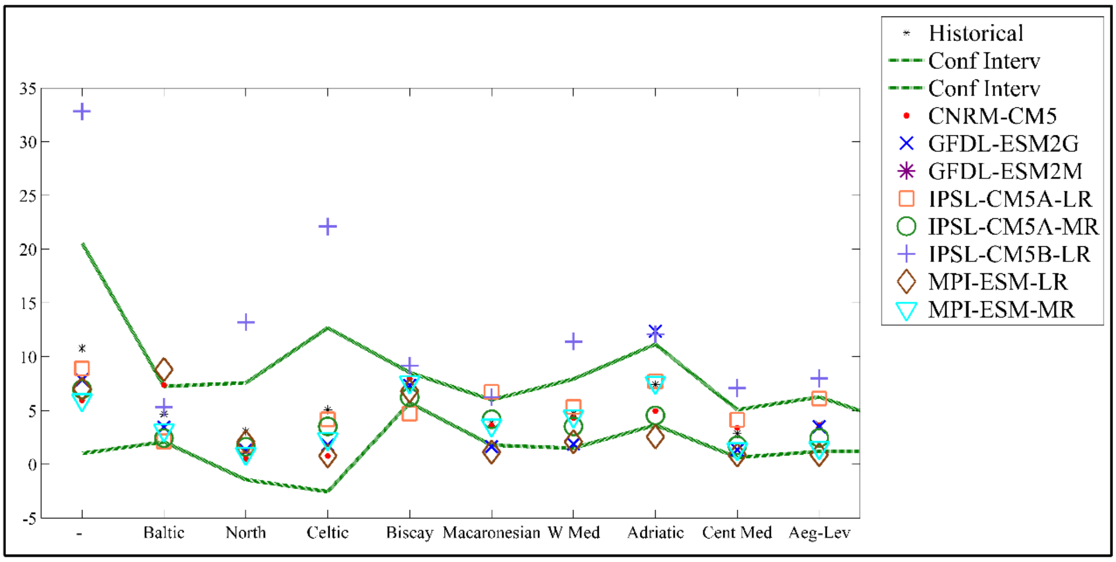

Fig. A.3 Mean squared error of General Circulation Models (represented according to legend) for sea surface temperature values in each Marine Strategy Framework region. Black asterisk represents the historical values obtained from sources in Table 1 and green lines their confidence intervals.

AIR TEMPERATURE

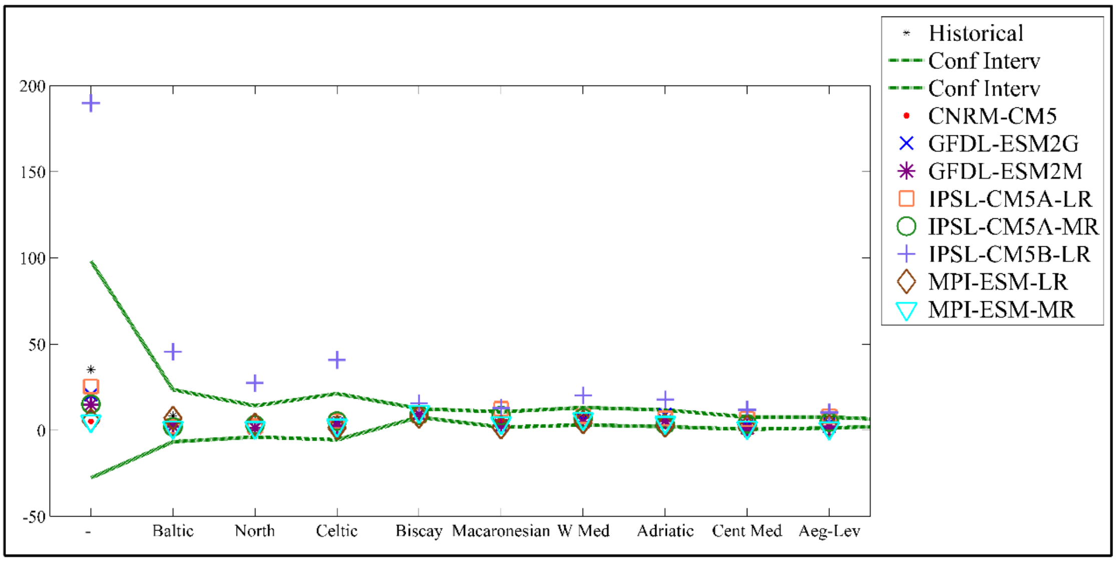

Fig. A.4 Mean squared error of General Circulation Models (represented according to legend) for air temperature values in each Marine Strategy Framework region. Black asterisk represents the historical values obtained from sources in Table 1 and green lines their confidence intervals.

WIND SPEED

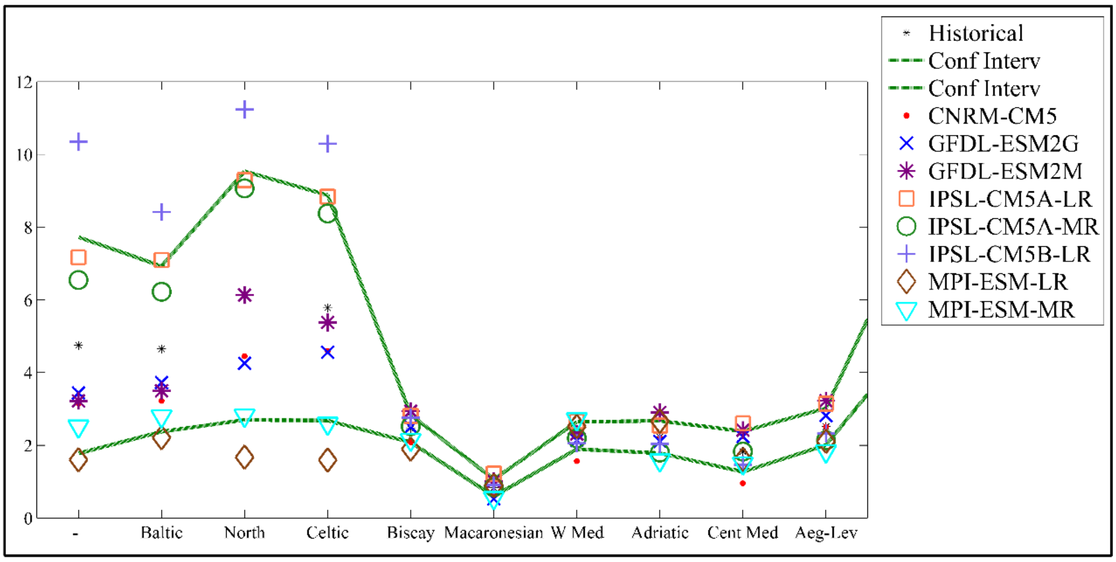

Fig. A.5 Mean squared error of General Circulation Models (represented according to legend) for wind speed values in each Marine Strategy Framework region. Black asterisk represents the historical values obtained from sources in Table 1 and green lines their confidence intervals.

SIGNIFICANT WAVE HEIGHT (Hs)

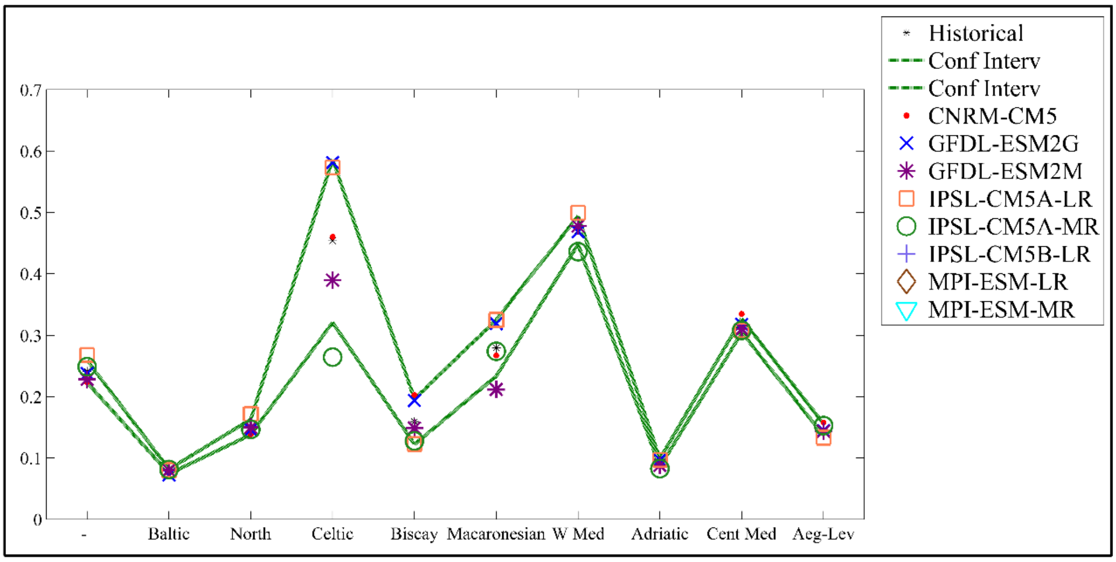

Fig. A.6 Mean squared error of General Circulation Models (represented according to legend) for significant wave height values in each Marine Strategy Framework region. Black asterisk represents the historical values obtained from sources in Table 1 and green lines their confidence intervals.

APPENDIX B. General Circulation Models (GCMs) information

Table B.1. General Circulation Models used in this work with indication of the developers institutions, their countries, resolutions and links to information.

General Circulation Model	Institution	Country	Atmospheric resolution (lat x lon, number of layers)	Link
CNRM-CM5	Centre National de Recherches Météorologiques	France	1°L42	1
GFDL-ESM2G	NOAA Geophysical Fluid Dynamics Laboratory	USA	1°L63	2
GFDL-ESM2M	NOAA Geophysical Fluid Dynamics Laboratory	USA	1°L50	2
IPSL-CM5A-LR	Institute Pierre Simon Laplace (IPSL)	France	1.9° x 3.75° (96 x 96 L 39)	3
IPSL-CM5A-MR	Institute Pierre Simon Laplace (IPSL)	France	1.25° x 2.5° (143 x 144 L 39)	3
IPSL-CM5B-LR	Institute Pierre Simon Laplace (IPSL)	France	1.9° x 3.75° (96 x 96 L 39)	3
MPI-ESM-LR	Max Planck Institute for Meteorology (MPI-M)	Germany	1,5°L40	4
MPI-ESM-MR	Max Planck Institute for Meteorology (MPI-M)	Germany	0,4°L40	4

LINKS

1. http://www.umr-cnrm.fr/spip.php?article126&lang=en
2. https://www.gfdl.noaa.gov/earth-system-model/
3. http://icmc.ipsl.fr/index.php/icmc-projects/icmc-international-projects/international-project-cmip5
4. https://www.mpimet.mpg.de/en/science/models/mpi-esm.html

HIGHLIGHTS

- OCLE provides abiotic biologically-meaningful information for marine studies.
- Historical and projected data was calculated for 16 variables and 12 parameters.
- European seas are covered at high temporal and spatially resolution.
- Quality control was established to ensure data accuracy.
- Data are freely available at http://ocle.ihcantabria.com.

Graphical abstract