Development of an assesSment tOol for predicting the dynamic riSk of drowning on bEAcheS

- *SOSeas* -

Usefulness of the Copernicus Marine Service Products

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List of Acronyms

API	Application Programming Interface
ANN	Artificial Neural Networks
C3S	Copernicus Climate Change Service
CMEMS	Copernicus Marine Environment Monitoring Service
DIAS	Data Information Access Service
DSS	Decision Support System
ETL	Extract, Transform & Load
GFS	Global Forecast System
M2M	Machine to machine communication
NOAA	National Oceanic and Atmospheric Administration
OGC	Open Geospatial Consortium
PWA	Progressive Web App
SDGs	Sustainable Development Goals
SOBRASA	The Brazilian Life-Saving Society
TDS	THREDDS Data server
UX	User Experience
UI	User Interface
WEkEO	We knowledge Earth Observation
WCS	Web Coverage Service
WMS	Web Map Service

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1 INTRODUCTION

The environmental information produced daily by the Copernicus Programme holds huge potential for the creation of real-time insights for decision support. The Copernicus Marine Environment Monitoring Service (CMEMS) provides regular and systematic reference information on the physical state and dynamics of the ocean and marine ecosystems for the global ocean and the European regional seas.

The SOSeas Service focuses on the development of an operational service based on the CMEMS products to prevent one of the major public health problem worldwide, ***drowning***. According to the World Health Organization (WHO), drowning is among the ten leading causes of death for children and young people in every region of the world. It is estimated that there are 360,000 annual deaths from drowning all around the world, although, global estimates may significantly underestimate the real problem of public health related to drowning.

The seventeen UN **Sustainable Development Goals** (SDGs) were proposed at the United Nations Conference on Sustainable Development in Rio de Janeiro in 2012 to meet the urgent environmental, political and economic challenges facing the world. Goal 3 of the SDGs focuses on "ensuring healthy lives and promoting the well-being at all ages". The downstream service proposed helps to reduce the third leading cause of unintentional injury death worldwide; designing, developing and implementing an operational assessment tool that provides electronic flags based on the dynamic risk of drowning on beaches using CMEMS data and Artificial Intelligence (AI).

2 CMEMS PRODUCTS IN THE SOSEAS SERVICE

The development of the SOSeas service was divided in three main tasks: (1) cross cutting analysis of the beach characterization, catalogue of drowning events and metocean conditions, (2) design and development of an expert system, based on the implementation of ANN to obtain electronic flags, and (3) design, development and implementation of the forecasting flag system. Each of these three tasks can be identified in Figure 1.

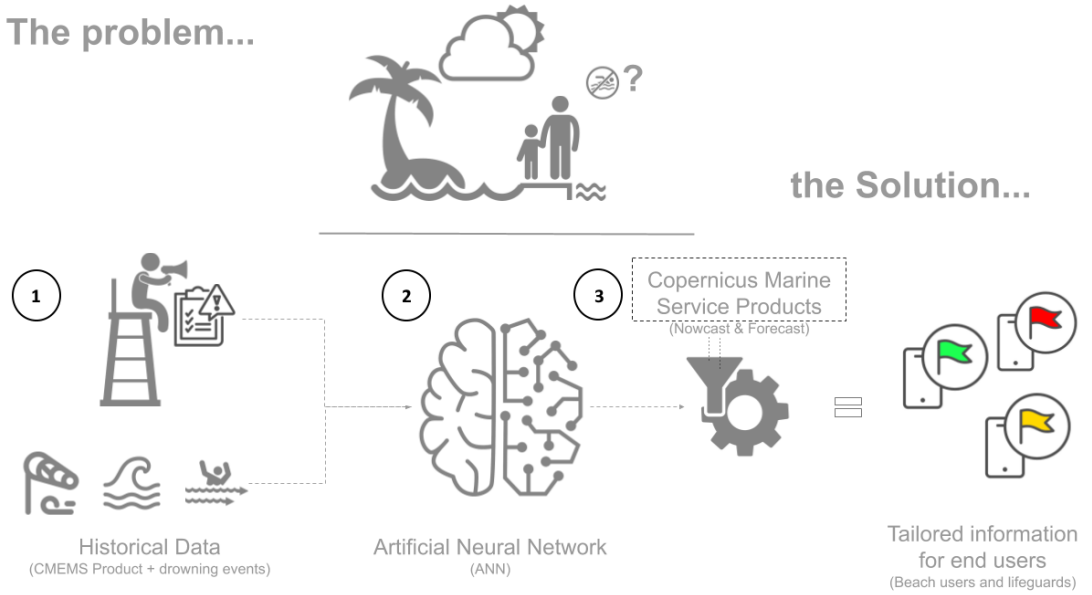

Figure 1. Conceptual scheme of the SOSeas Service

CMEMS products are used in two key steps: (1) the cross validation between marine climate data and historic flags and (2) the flag forecasting analysis, in which CMEMS forecasting products are used as an input to calculate the forecasting flags.

2.1 CROSS VALIDATION BETWEEN LIFEGUARDS DATABASES AND MARINE CLIMATE

The Fire Department of Santa Catarina Military Police is in charge of the Santa Catarina beaches surveillance. During the last 18 years, lifeguards from the Fire Department have collected more than 132.000 observations from 139 coastal beaches, which have 346 lifeguard posts. The Fire Department has provided the observation to SOBRASA in order to undertake the SOSeas Service. This information has been provided in two databases: a database of events (drownings or similar) and a database of status flag at each lifeguard post.

The events database contains 52.712 records from January 2001 to May 2019, whereas the Flags database contains 79.487 records from November 2016 to July 2019.

The Event database has been crossed with the different type of beaches and orientation in order to obtain a classification of the most dangerous type of beach based on its morphological modal state. Table 1 shows the variables selected and the source of information.

Geomorphological variables	
Variables	**Source**
Morphological modal state	Literature – (IHCantabria 2013, Short 2016)
Beach orientation	Digitalisation with satellite images
Presence of estuary/river mouth	

Table 1. Geomorphological variables

In the case of marine climate information, Global Ocean Wave Reanalysis WAVERYS (GLOBAL_REANALYSIS_WAV_001_032) and ERA5 (C3S) products have been crossed with beach flag and events database in order to obtain useful relations between these variables for the development of the assessment tool for predicting the dynamic risk of drowning on beaches. Table 2, shows the variables selected and the product provider.

Reanalysis metocean variables		
Type	**Variables**	**Product – Provider**
Waves	Significant total weight Hs	GLOBAL_REANALYSIS_WAV_001_032 – **CMEMS**
	Mean wave period Tm	
	Direction of waves	
Wind	Magnitude of wind velocity	ERA 5 – C3S
	Direction of winds	
Water level	Water level variation	TPXO – (http://volkov.oce.orst.edu/tides/)
Currents	Magnitude of marine currents	GLOBAL_REANALYSIS_PHY_001_030 – **CMEMS**

Table 2. Reanalysis metocean data

2.2 FORECASTING FLAG ANALYSIS

Once the ANN has been designed, it allows obtaining electronic bathing flags as a risk assessment indicator. Table 3 provides the variables and product provider that have been implemented into the SOSeas Service.

		Forecast metocean variables
Type	**Variables**	**Product – Provider**
Waves	Significant total weight Hs	GLOBAL_ANALYSIS_FORECAST_WAV_001_027 – **CMEMS**
	Mean wave period Tm	
	Direction of waves	
Wind	Magnitude of wind velocity	Global Forecast System (GFS) – NOAA
	Direction of winds	
Water level	Water level variation	GLOBAL_ANALYSIS_FORECAST_PHY_001_024 – **CMEMS**
Currents	Magnitude of marine currents	

Table 3. Forecast metocean data

2.3 SUMMARY OF CMEMS PRODUCTS USED

The Copernicus Marine Service provides regular and systematic core reference information on the state of the physical oceans and regional seas. The daily observations and forecasts produced by the Copernicus Marine Service support the SOSeas Service with the required metocean data to provide the dynamic hourly risk assessment (forcasting flags). Copernicus Marine Service reanalysis products have been used to train the Artificial Neural Network, whereas Copernicus Marine Service forecasting products are used to provide the forecasting risk assessment.

Copernicus Marine Service products http://marine.copernicus.eu/ are key elements of the downstream service. The SOSeas Service makes use of the following products:

- Global Ocean Physics Reanalysis (GLOBAL_REANALYSIS_PHY_001_030)
- Global Ocean Wave Reanalysis WAVERYS (GLOBAL_REANALYSIS_WAV_001_032)
- Global Ocean Waves Analysis and Forecast Updated Daily (GLOBAL_ANALYSIS_FORECAST_WAV_001_027)
- Global Ocean 1/12º Physics Analysis and Forecast Updated Daily (GLOBAL_ANALYSIS_FORECAST_PHY_001_024)

3 REFERENCES

IHCantabria, 2013. SMC-Brasil: Documento Temático de Recuperacao de Praias. Ministério do Meio Ambiente. URL http://smcbrasil.ihcantabria.com/downloads/

Short, A.D., da F. Klein, A.H. (eds.), 2016. Brazilian Beach Systems, *Coastal Research* Library 17, DOI 10.1007/978-3-319-30394-9_17.