Sentinel-3 products for detecting EUtROphication and Harmful Algal Blooms in the French-English Channel (S-3 EUROHAB).

TASK 2. Activity 2.4: Deliverable 2.4.1. Report on the accuracy of the S-3 EUROHAB web alert system.

Stephanie Allen[1], Gavin Tilstone[1], Andrey Kurekin[1], Silvia Pardo[1], Peter Miller[1], Claire Widdicombe[1], Tania Hernandez-Farina[2], Catherine Paul[3], Francis Gohin[4], Mike Best[5].

[1]PML - Plymouth Marine Laboratory, Prospect Place, The Hoe, Plymouth, PL1 3DH, UK.

[2]IFREMER – Institut Français de Recherche pour l'Exploitation de la Mer, Centre de Port en Bessin, Avenue du Général de Gaulle BP 32, 14 520 Port-en-Bessin, France.

[3]CRPN - Comité Régional des Pêches de Basse Normandie, 9 Quai Général Lawton Collins, 50100 Cherbourg-Octeville, France.

[4]IFREMER – Institut Français de Recherche pour l'Exploitation de la Mer, Centre de Bretagne, CS 10070, 29280 Plouzané, France.

[5]Environment Agency, Aqua House, East Station Road, Peterborough, Cambridgeshire PE2 8AG, UK.

Summary:

Anthropogenic impacts on the marine environment, such as land-use impact on river-run off and climate change, have the potential to alter phytoplankton abundance and succession in the marine environment. Globally, these changes have led to the increased frequency and magnitude of harmful algal blooms (HABs) and have resulted in a decrease in marine water quality. This can have a detrimental effect on the shellfish and aquaculture industry through the accumulation of algal toxins in shellfish, and de-oxygenation of the water column. HABs can lead to the closure of shellfish beds, which if not regulated, can have direct impacts on human health.

A web alert system to detect HABs and water quality in the French-English Channel using satellite data has been developed within the INTERREG-VA FCE project S-3 EUROHAB (https://www.s3eurohab.eu/portal/). It is the first of its kind in Europe to utilise the European satellite, Copernicus Sentinel-3 (S-3), to track the development, magnitude and spread of HABs in the French-English Channel. Following stakeholder consultation, it provides near real-time risk indicator maps of three HAB species (*Karenia mikimotoi*, *Phaeocystis globosa*, *Pseudo-nitzschia* spp.) for the French-English Channel at both high (300 m; Sentinel-3 OLCI) and low resolution (1 km; NASA MODIS-Aqua and VIIRS-Suomi NPP). It also provides water quality indicators; Chlorophyll-*a* (a proxy for phytoplankton biomass), Particulate Inorganic Carbon and Turbidity as proxies for eutrophication and low water quality. Meteorological and physical parameter maps of rainfall, wind speed and direction, seawater temperature, salinity and ocean mixed layer thickness are also available.

The objective of this task is to assess the accuracy of the products available from the S-3 EUROHAB web alert system. Preliminary results indicate that HAB risk maps from the NASA satellite MODIS-Aqua of *Karenia mikimotoi and Phaeocystis globosa* compared to *in situ* cell abundance data are accurate. For *Pseudo-nitzschia* the HAB risk indicator available for both MODIS-Aqua and S-3 OLCI are less accurate. For MODIS-Aqua *Pseudo-nitzschia*, the HAB risk indicator is currently more accurate than the S-3 OLCI HAB risk indicator. The reasons for this partly arise from the training data available for each satellite sensor; MODIS-Aqua was launched in 2002, whereas S-3 OLCI was launched in 2016. There is therefore more training data available for each species for MODIS-Aqua than for OLCI. Now that more data is available for OLCI, a re-training of HAB risk for *Pseudo-nitzschia* is currently being undertaken for S-3 OLCI and also for the more recent NASA satellite VIIRS to improve the accuracy of these products.

S-3 EUROHAB is also investigating the link between the *Pseudo-nitzschia* HAB risk maps and the Amnesic Shellfish poisoning toxin Domoic Acid, which is released into the water column by *Pseudo-nitzschia* spp.. The web alert system is being further tested in pilot operations in the Bay of Seine, and in future operations along the Devon coast, to evaluate the utility and effectiveness of the system for managing their operations. These Pilot Operations were delayed during 2020 due to the COVID-19 global pandemic. Potentially, the S-3 EUROHAB web alert system would enable marine managers and the shell fishing industry to monitor changes to the marine environment more rapidly than can currently be achieved. It

would also enable faster reaction and mitigation times as HABs develop, which would potentially save shell fish stock and thus commercial revenue.

The accuracy of the water quality products available from S-3 OLCI have also been assessed. Satellite ocean colour water quality products are estimated from remote sensing reflectance [$R_{rs}(\lambda)$] across the visible spectrum that are measured directly on-board the satellite. The first step in the verification of the products is to assess the accuracy of $R_{rs}(\lambda)$. 26000 $R_{rs}(\lambda)$ spectra were measured from the Research Vessel (R/V) *Quest* in the western French-English Channel and from these, 113 clear sky S-3 OLCI passes were acquired within 1.5 hours of the *in situ* $R_{rs}(\lambda)$ measurements. The corresponding S-3 OLCI full resolution level 2 products were downloaded from the EUMETSAT Data Centre and Copernicus Online Data Access (CODA). S-3 OLCI processing baseline (pb) 2 and 3 (released in February 2021) for open ocean waters, C2R-CC for coastal waters and POLYMER v4.13, an alternative atmospheric correction (AC) processor, as well as the corresponding NASA MODIS-Aqua and VIIRS products were assessed. Preliminary results show that S-3 OLCI pb 3 provides the most accurate $R_{rs}(\lambda)$. This algorithm will theoretically generate the most accurate Chl-*a* for French-English Channel water quality products.