Annex 4: ToR E: New Findings

Update on satellite techniques for monitoring for HABs

Peter Miller

The aim was to inform the WG about several ongoing UK and European projects developing Earth observation (EO) techniques for detecting HABs. **ShellEye** is developing a subscription service to provide early warning of water quality risks to aquaculture (mainly shellfish) farmers, via regional bulletins sent by e-mail, focused initially on the UK region. The bulletins comprise satellite monitoring and detection of certain dense HABs. It is also generating long-term satellite HAB risk maps for potential use by marine insurers. (Funded by UK research councils BBSRC and NERC). **S-3 EUROHAB** is developing a web-based alert system to track the growth of potential HABs, for marine managers, regulators, and the fishing industries within the French/English Channel region. The project is also creating a cross-border monitoring network and data portal for monitoring water quality, incorporating Sentinel-3 satellite data as well as *in situ* monitoring, and physical and ecosystem modelling. (Funded by Interreg France/England Channel.) **PRIMROSE** is to provide local HAB forecast bulletins for the aquaculture industry, based on hydrodynamic models, EO data on algal blooms, or linking these two approaches. (Funded by Interreg Atlantic Area, extending an earlier FP7 project ASIMUTH). Finally, TAPAS is supporting future sustainable aquaculture, including modelled ecosystem scenarios and environmental indicators such as the long-term risk of HABs. (Funded by EU Horizon 2020.). Peter summarised the current status of EO sensing of HABs, with the recent launch of the second ESA 300m resolution ocean colour sensor, the clear benefits of EO monitoring for salmon farming, and the need for continuing research effort to develop similar benefits for shellfish farming, combining with modelling to overcome the limitations of EO.

Dynamics of toxic phytoplankton species along the Catalan coast (NW Mediterranean Sea)

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There is a general concern that HABs are increasing worldwide maybe as a consequence of some factors favoring proliferations or maybe due to an increase of sampling efforts and the improvement of detection methods. To solve this question, studies on the dynamics of these algal species are required in places with a similar frequency sampling over a long period of time. Using time series of phytoplankton from several stations along the Catalan coast (NW Mediterranean), we analyze the trends of potentially toxic species. The objective was to determine if the proliferations of toxic species increased during the study period (2000-2012) along the Catalan coast.

While the blooms of potentially PSP producer species, increased in general in many of the confined stations studied, due to the increase of A. minutum, the A. pacificum were not more detected in most of the stations during the last years of the study period. The blooms of DSP producer species did not shown an increase but there was also a clear increase in the number of blooms of the genus Pseudo-nitzschia (genus with species po-

tentially producing ASP toxicity) as a consequence of the increasing abundances in most of the confined stations.

Bioanalytical devices for the rapid, reliable and cost–effective detection of toxic microalgae

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Biotechnological tools for the detection, discrimination and quantification of toxic microalgae have been developed in the framework of the Spanish projects SEASENSING AND CIGUASENSING (BIO2014-56024-C2-2-R and BIO2017-87946-C2-2-R, MINECO). The targeted microalgae have been *Karlodinium veneficum* and *Karlodinium armiger*, *Ostreopsis ovata* and *Ostreopsis siamensis*, and *Gambierdiscus*/*Fukuyoa*.

Different formats have been designed: colorimetric assays on microtiter plates, electrochemical biosensors and visual strip tests. All biotechnological tools include an isothermal DNA amplification step using tailed primers, followed by a sandwich hybridisation assay. The isothermal DNA amplification uses recombinase polymerase enzymes and is able to operate at low constant temperature (37 °C). In this process, a duplex amplicon is formed, with a tail that hybridises with a capture probe immobilised on a plate or on a magnetic bead (used as a support for the immobilisation on electrodes), and another tail, at the other extreme, that hybridises with a reporter probe. After enzyme substrate incubation, colorimetric and electrochemical measurements are recorded. Seawater and macrophyte samples have been analysed using these approaches, and results have been compared with qPCR and light microscopy, showing appropriate correlations.

Novel widespread oomycetes parasitising diatoms, including the toxic genus *Pseudo–nitzschia*: genetic, morphological and ecological characterisation

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Parasites are key drivers of phytoplankton bloom dynamics and related marine ecosystem processes. Yet, the dearth of morphological and molecular information hinders the assessment of their diversity and ecological role. Using single-cell techniques, we characterise morphologically and molecularly intracellular parasitoids infecting four potentially toxin producing *Pseudo-nitzschia* and one *Melosira* species on the North Atlantic coast. These sequences define two novel, morphologically indistinguishable, clades within the phylum Oomycota, related to the genera of algal parasites *Anisolpidium* and *Olpidiopsis* and the diatom parasitoid species *Miracula helgolandica*. Our morphological data are insufficient to attribute either clade to the still unsequenced genus *Ectrogella*; hence it is proposed to name the clades OOM_1 and OOM_2. A screening of global databases of the barcode regions V4 and V9 of the 18S rDNA demonstrate the presence of these parasitoids beyond the North Atlantic coastal region. During a biweekly metabarcoding survey of the Concarneau Bay (France), barcodes associated with the sequenced parasitoids coincided with the decline of *Pseudo-nitzschia* spp. and *Cerataulina pelagica* blooms. Our data highlight a complex and still unexplored diversity of oomycete parasitoids of diatoms and calls for the investigation of their phenology, evolution, and potential contribution in controlling their host spatial-temporal dynamics.