Towards a HAB forecast service in the Galician region

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ABSTRACT

We will present the recent developments of our forecasting capabilities to warn of impending harmful algal blooms (HABs) in Galicia, where aquaculture has a strong socio-economic impact. A HAB warning service for monitoring agencies and the aquaculture industry has been developed as a demonstration of a Copernicus marine downstream service coupled to the MyOcean service. In this contribution, we describe the Galician ASIMUTH forecast system and demonstrate its skill in predicting HAB transport and its usefulness to provide assessment for the management of the areas affected by toxic outbreaks. We also describe the Galician pilot HAB bulletins, aimed at distributing forecasts of HAB events that might induce closures of harvesting areas or, when the areas are already closed, at giving information on forthcoming oceanographic conditions that could favour or hamper the opening of an area. Our results show that the model forecasts and the bulletins can provide early warning of the risk of *Dinophysis spp.* events and the risk of closures linked to the presence of toxins above regulatory levels in harvesting areas.

INTRODUCTION

IEO is a public research institute founded in 1914 and devoted exclusively to marine related studies including fisheries, aquaculture and marine environment studies. IEO routinely performs monitoring of hydrography, plankton, fisheries and pollutants along the Spanish coasts. IEO maintains a large observing system for monitoring of oceanographic and biological properties around the Iberian Peninsula and Islands [1]. As a development for supporting users in different domains, a suite of products for the general public, and more specific for the aquaculture, marine leisure, fishing and commercial users, are available in the web portal http://www.indicedeafloramiento.ieo.es. With downscaled models IEO is producing upwelling indexes, frontal maps for fisheries and beach status information for marine leisure pursuits (http://playas.ieo.es). Data and products are disseminated through web applications some of them ready for smart phones.

During the ASIMUTH project, an effort was made to develop products that characterize the oceanographic conditions during periods of HABs and that help forecast the risk of impending HABs. At the North-western Iberian coast, HAB events (mainly *Dinophysis spp.*) are a recurrent phenomena throughout the whole year, leading to closures of harvesting areas in a region where aquaculture has a strong socioeconomic impact. Pilot bulletins for early warning of HAB events in the Galician shelf and rías were developed during ASIMUTH to respond to the demand of specific HAB forecasts (monitoring agencies and the aquaculture industry) [2]

MATERIAL & METHODS

Over the past ten years, the Coastal Ocean Modelling Group at IEO has gained wide experience in the simulation of the circulation of the NW and N Iberian shelf and slope using the Regional Ocean Model System (ROMS). In its present forecast configuration, the models is being run routinely with atmospheric data supplied by the regional weather service (MeteoGalicia, http://www.meteogalicia.es). Open boundaries and initial conditions are obtained from a large scale model, the operational forecasting system for the North Atlantic (PSY2V4/Mercator Ocean) in the MyOcean Copernicus Marine Service. The operational grid domain spans from the Atlantic (from Cape S. Vicente, Portugal) to the Cantabrian Sea shelves (up to Gijón, Spain), with a 4 km resolution. A higher resolution 1.3 km grid centred in the Galician coast runs nested. This system provides water temperature, salinity, surface elevation, currents and fluxes with a 3 day forecast range. The model configuration has been extensively compared with data and it has shown skill in simulating the observed variability of shelf and slope processes in the area [2,3] Another pre-operational configuration, developed during the ASIMUTH project, runs with a 3.5 km resolution and extends to the French shelf. A N2PZD2 biochemical model is run coupled to the physical model and provides results of nutrients, chlorophyll, phytoplankton and zooplankton [3].

The Galician HAB forecast system gathers data on the status of harvesting areas (open or closed) and about the presence of toxic species and also information on the current oceanographic conditions from in-situ

measurements and satellite imagery. This is combined with the analysis of the results of high resolution local numerical model predictions that help characterise along-shore and across-shore transport. Experts use this information and their knowledge to issue a prediction of where a HAB is "likely" to result in closures of harvesting areas. We have performed hindcast and forecast simulations for different periods that show that the forecast system is able to describe and predict across and along-shore transport affecting harvesting sites in Galicia and their variability and therefore can provide assessment for monitoring agencies and the aquaculture industry to implement protective measures on time.

RESULTS & DISCUSION

Can our system provide an early warning of HAB events?
The main species causing toxic outbreaks in Galicia are the dinoflagellates *Dinophysis spp*. (*D. acuminata* and *D. acuta*) and Gymnodinium catenatum; associated with diarrhetic (DSP) and paralytic shellfish poisoning (PSP) events. *D. acuminata* appears in the rías linked to the beginning of the upwelling season and persists throughout the upwelling season; variations in cell numbers are associated with wind event variability.. It is known that highest net growth of *D. acuminata* is observed during relaxation and downwelling following upwelling events. During ASIMUTH we have demonstrated that the forecast model is able to describe in detail the oceanographic conditions in response to upwelling-downwelling cycles and the interplay of different physical forcing (wind events, tides...). The forecast model is therefore able to warn of the conditions favourable for *D. acuminata* growth: upwelling events (favourable for the growth of its prey *Mesodinium spp.*) followed by retention in the rias (favourable for the encounter of *Dinophysis* and *Mesodinium*). Particularly, the model is able to warn of potentially rapid changes in cell densities linked to shifts in winds. Therefore, we can put forth that the forecast model can warn of the risk of a DSP event by *D. acuminata* that might cause the closing of harvesting areas.
In contrast to *D. acuminata, D. acuta* and *G. catenatum* are very seasonal and appear at the autumn transition from upwelling to downwelling favourable conditions as sudden blooms that have been linked to along-shore advection of shelf waters. Autumn blooms cause high economic losses to the shellfish industry when closures last for several months, including the winter (Christmas) harvest season, when sales are at their peak. In this contribution we will show hindcast simulations of the dinoflagellate blooms during the autumns of 2005 and 2013. The presence of *D. acuta* in 2005 and 2013 and of *G. catenatum* in 2005 on the northern Portuguese shelf in the summer of the two years was detected by the Portuguese monitoring system. In October 2005 and September 2013, these toxic species suddenly appeared in Galicia. The ASIMUTH system was able to forecast along-shore advection associated with the arrival of autumn HABs to Galicia in both years. In Figure 1 we can see that the forecast system predicted northwards transport on the shelf on the days before 30 September 2013 able to transport HAB populations from Portuguese waters. This is clearly seen both in along-shore sections and in the results from the Lagrangian simulations tracking particles emitted on the shelf from the latitudes of the northernmost Portuguese bivalve monitoring areas

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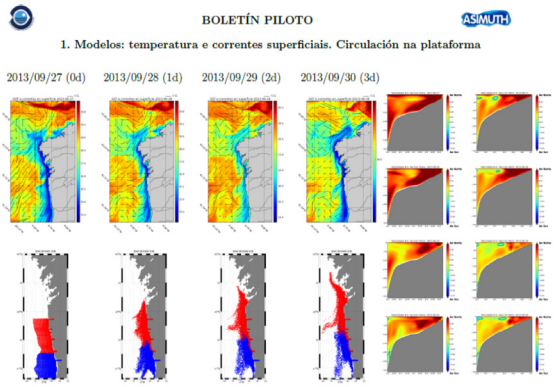

Fig. 1. Galician Pilot HAB Bulletin page for Friday 27 September 2013. Top panel: 3-day forecasts of model generated SST and velocities. Bottom left panels: 3-day evolution of particles released from the two northernmost Portuguese bivalve monitoring areas Left panel: 3-day forecast of north-south velocities (red and blue respectively) along cross-shore sections at the central latitudes of the Portuguese monitoring areas (left, Viana, right, Porto)

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