Note on the real-time time detection of a Karenia mikimotoi bloom from space in the Western English Channel in July 2010

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Task 3108, Water Quality Monitoring of the English Channel and the Bay of Biscay

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Context

Karenia mikimotoi is a dinoflagellate common in the Eastern North Atlantic Ocean, particularly in summer. Recent *K. mikimotoi* blooms in Western Ireland (Silke et al., 2005), Scottish waters (Davidson et al., 2006), and the English Channel (Vanhoutte-Brunier et al., 2008) have been reported and described. This dinoflagellate is feared as it may impact the marine animal population directly, through its haemolitic cytotoxin, or indirectly through hypoxia during the degradation of the bloom when its biomass is high. In 2003, a major *K. mikimotoi* bloom, visible from space, occurred from the end of June to the beginning of August offshore in the Western English Channel. The bloom started between Northern Brittany and Cornwall. It then developed eastward as the thermal stratification set up and favoured its habitat, progressing easterly with the season. Despite the considerable cell concentration level, the damages were limited as the bloom was mainly offshore. No apparent damage was reported in the Channel Islands and only some dead fish and visible stress in the growth of some shellfish species, for instance Pecten maximus, were reported.

Some *K. mikimotoi* blooms are at too great a depth, or are not large enough to be visible from space. However, some reach such an extent and have a sufficiently high concentration of pigment and particles in the surface waters that they can be observed by space-borne Ocean Colour sensors as SeaWiFS, MODIS/AQUA a,d MERIS. At this size and density of bloom it may also be possible in some conditions to discriminate *K.mikimotoi* from other species (Miller et al., 2006).

Observation of the K. mikimotoi bloom and alert

The surveillance through the MarCoast2 project

Ifremer has been monitoring coastal waters from space for many years using SST, chlorophyll and turbidity levels derived from satellite observations. Satellite data are provided thanks to the Ocean Colour TAC (Thematic Assembly Centre) of MyOcean. MyOcean is funded by the European Commission under the 7th Framework Program. This project aims to provide and evaluate the marine reference observations needed to fulfil the requirements of the GMES program (Global Monitoring for Environment and Security). The monitoring, the analysis, and the delivering of the satellite information through a WEB-server dedicated to coastal seas is managed by the MarCoast2 project. MarCoast2, a successor to the ROSES and MarCoast projects, is a GMES –Service Element funded by ESA (European Space Agency) and is aimed at supporting and developing exchanges between European coastal seas satellite-data providers and users of that information. At Ifremer, there are two main applications for the

information handled by MarCoast2. The first addresses long term surveillance requirements (for the Water Framework Directive and the European Maritime Strategy) and the second provides rapid alert in case of eutrophication or HAB (Harmful Algal Bloom). This second task is also linked with Previmer, the French coastal oceanography project, for Ifremer.
HABs in the coastal waters around France are seldom visible from space, due to their low cell concentration, deep location (*dynophysis*) or occurrence in narrow estuaries or lagoons (*Alexandrium*). The satellite imagery is also of limited use for the direct observation of toxic P*seudo-nitzschia* which is a diatom able to bloom in high concentration with very variable toxicity (producing domoic acid, an amnesic neurotoxin). The case *of K. Mikimotoi* in the English Channel is different as it may occur in high concentration over large areas, as in the western English Channel.

Observation of the *K. mikimotoi* bloom in July 2010 and the early alert

The bloom was clearly visible on the merged MERIS and MODIS chlorophyll map (MyOcean L4 product for the IBI-ROOS area) on July 15th (Figure1). Its appearance at a time when production generally decreases offshore following the consumption of nutrients in spring is a major event in the coastal seas of the western European waters

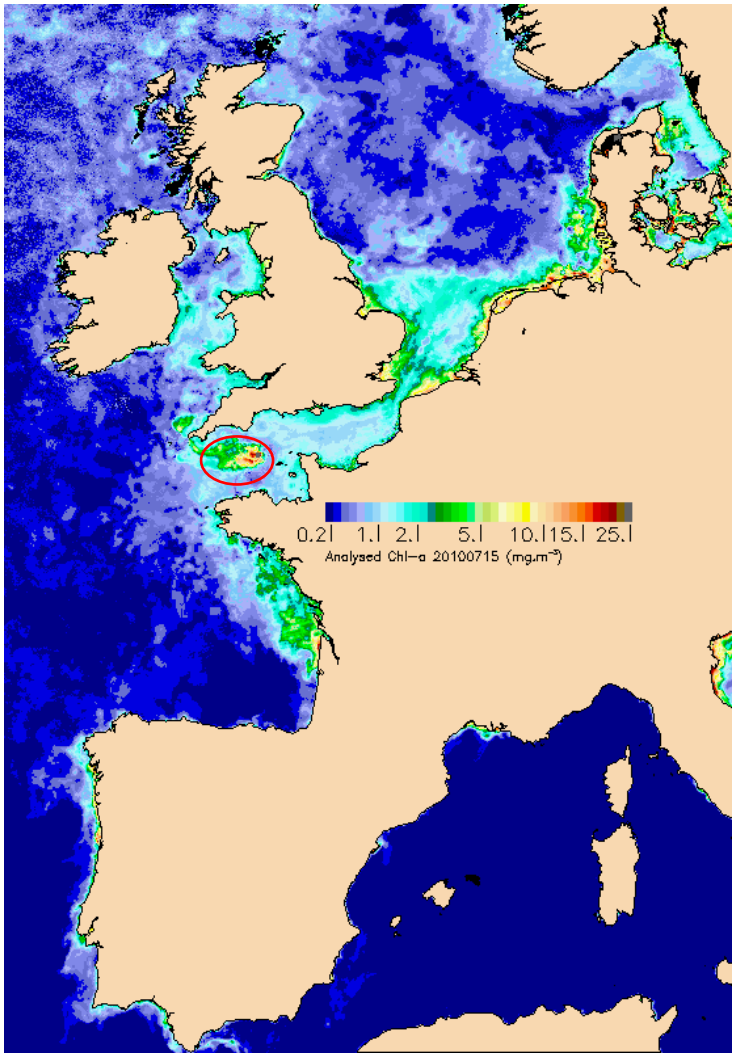


Figure 1: The K. mikimotoi bloom on the MERIS/MODIS synthesis map of chlorophyll July 15th

Figure 1 shows the bloom in the background of the phytoplankton concentration in European waters, but as the merged L4 product is obtained by a space-time interpolation, it is

recommended to use the daily Meris and Modis images from the CERSAT/MarCoast server

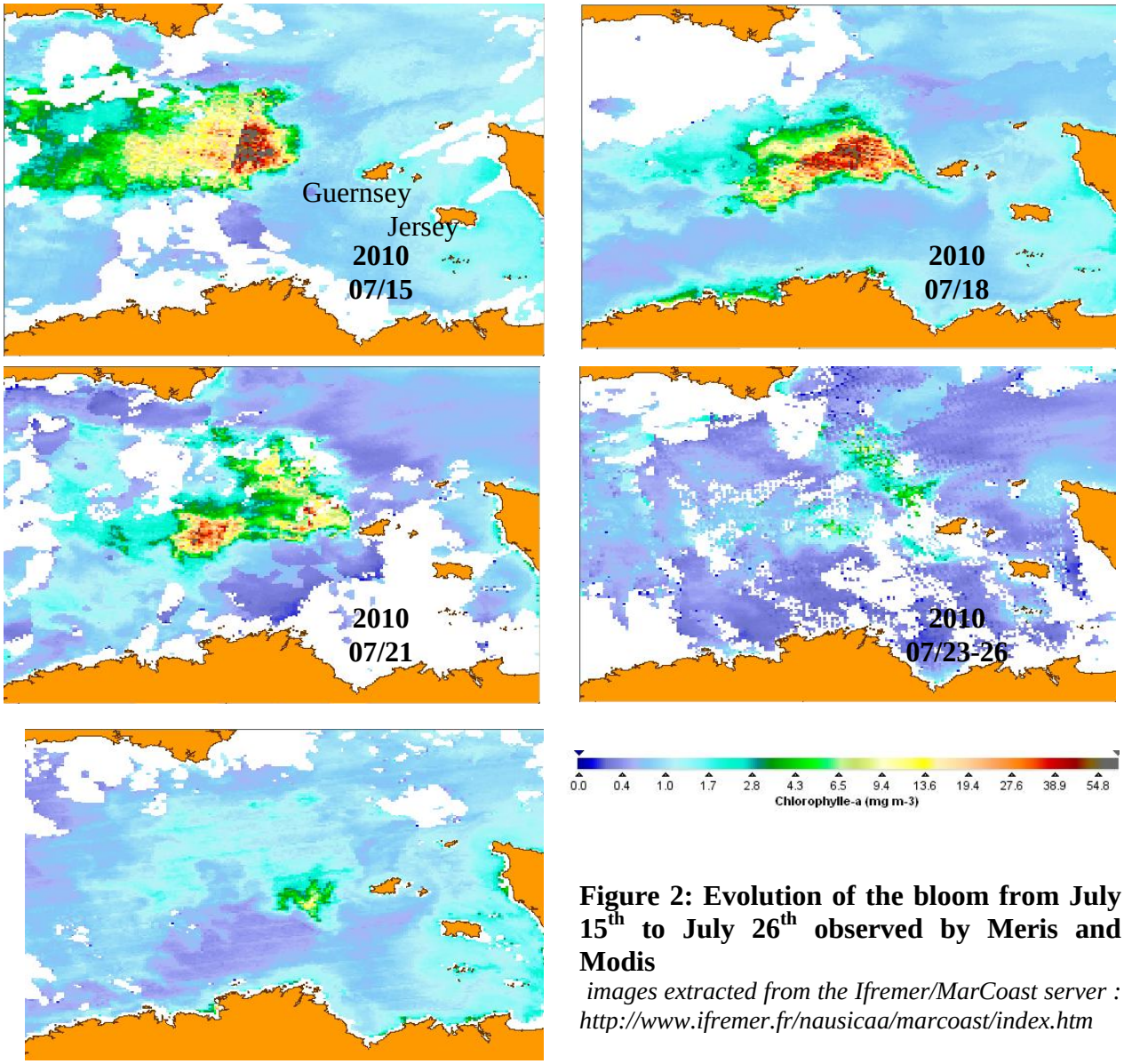


Figure 2: Evolution of the bloom from July 15th to July 26th observed by Meris and Modis

images extracted from the Ifremer/MarCoast server : http://www.ifremer.fr/nausicaa/marcoast/index.htm

Figure 2 shows the evolution of the bloom from July 15th to July 29th. We observe an apparent easterly drift of the bloom until July 26th. Although this drift seems to follow the mean residual current in the Channel, the cause of this evolution could actually be due to the progressive establishment of favourable conditions for the growth of dinoflagellates in the east of the area (Vanhoutte-Brunier et al., 2008). The thermal stratification (See temperature map and chart on figures 3 and 4) appears in the western English Channel and establishes progressively eastwards through the season. This stratification results from high solar irradiance and increased air temperature. A strong increase in the surface temperature appears clearly in the July SST chart of the Channel Light-Ship station (UK MetOf and MeteoFrance) extracted from the Puertos Del Estados server providing access to the data of the fixed stations in the IBI-ROOS area (Figure 4). The increase in temperature is particularly intense (4 degrees) from 6th to 10th of July.

High solar irradiance, providing more light and energy for photosynthesis at the pycnocline level, will also enhance the growth of the bloom. However, there is a part of the bloom which

is not dependent on stratification and is more directly related to local transport as shown by the tongue visible south of Guernsey on the image of July 18th.

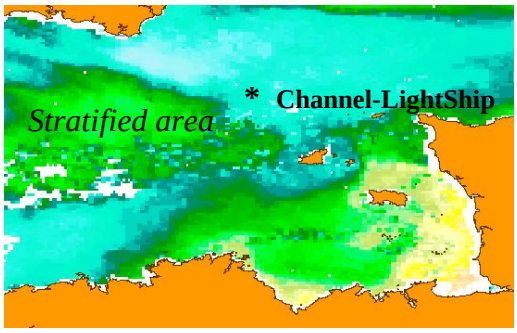


Figure 3:
The Sea Surface Temperature on July 17-18 extracted from the Ifremer/MarCoast server

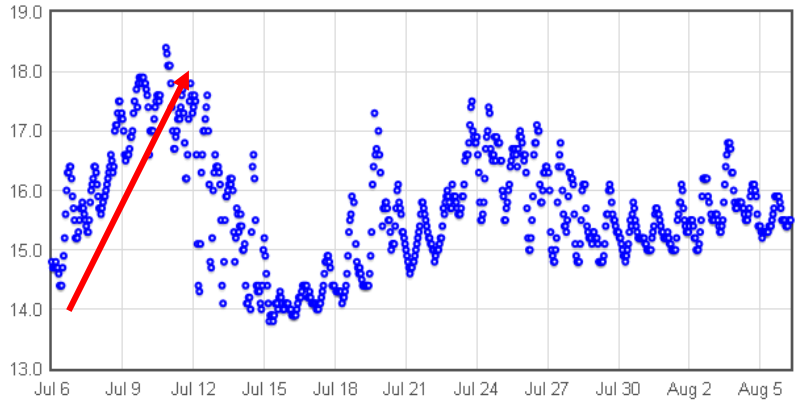


Figure 4:

Sea Surface Temperature at the Channel_LightShip station
(see Figure 3 for the position)

After July 21st, the sea surface temperature, under a covered sky, began to be lower than the seasonal mean. Few images are available during the period 22-26 of July. They show a scattered bloom, clearly decaying and recentering on the small area shown on the Modis image of July 29th. Brown strips (3-4 miles long) have also been reported by Cross-Jobourg, west of Cotentin (49° 55.3 N - 002° 05 W), on July 26th. 900 cells/L and 200 cells/L of *K. mikimotoi* have been observed by the REPHY network (Phytoplankton surveillance network of Ifremer) at Trebeurden and Loguivy (Northern Brittany) on July 21st.

The action after the alert from MarCoast and the analyses of CEFAS

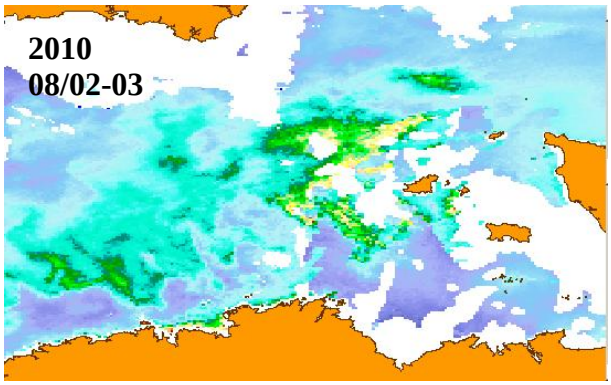
Following a high turbidity event in spring 2008, (attributed to two successive strong storms in December 2007 and March 2008) visible from space, four people from the Channel Islands registered on the MarCoast server (750 registered people from Western Europe at the end of July 2010). On July 19th they were informed by email that a phytoplankton bloom, possibly composed of *K. mikimotoi* was approaching Guernsey. The information reached the Fisheries Department of the States of Guernsey Government who informed the Environmental Health and Pollution Regulation Unit. Officers collected two samples in the surface waters, seven miles west of Guernsey on July 22th. These samples were sent to CEFAS Plankton Laboratory,

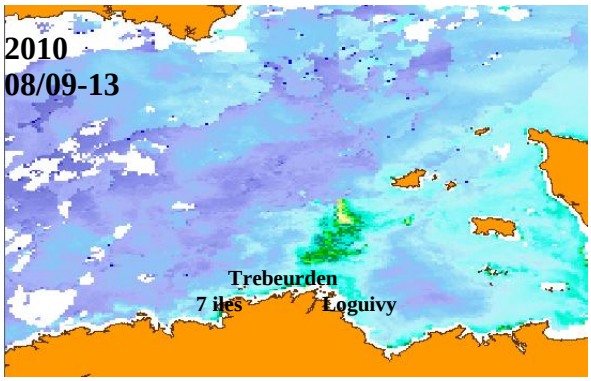
Lowestoft, Suffolk, for analysis. The results, known the 27th, showed 934000 and 1380000 cells of *K. mikimotoi*, 24200 and 9200 cells of pseudo-nitzschia, and 200 cells of dinophysis in one of the samples. The presence of dinophysis in quantity greater than 100 cells/litre requires additional biota and water samples from the contaminated site.

Decay of the bloom in August 2010

In August the meteorological situation was not favourable to the development of a *K. mikimotoi* bloom. Still visible between Brittany and Guernsey on MERIS/MODIS images of 9-13 August (Figure 5), the bloom has vanished on the image of August 16th.

K. mikimotoi has been observed in the sample of the 7 iles and Trebeurden stations of the Ifremer REPHY network in the first week of August (300 and 200 cells/Liter respectively reported by Aurélie Legendre)





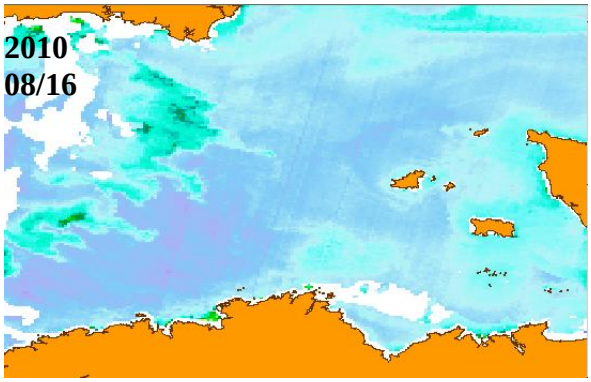


Figure 5: Evolution of the bloom in August 2010

Comparison with the *K. mikimotoi* bloom in summer 2003

As a bloom of *K. mikimotoi* could have been anticipated given the very similar environmental conditions to those prevailing in 2003, it is worth re-examining the evolution of the 2003 bloom observed from SeaWiFs and Modis while considering the climatic conditions during both years. High air temperature and solar irradiance were common characteristics in the 2003 and 2010 months of July. Figure 4 shows the surface temperature at Marel Iroise (near Brest) for the monitoring year leading up to July 2010 and the corresponding temperatures in 2003. The black curve is the mean for the 2000-2010 period, the dashed lines are the 10 and 90 percentiles. Although the variability and the seasonal amplitude of the temperature at this station is lower than on the western Channel, it shows that both winters were relatively cold (2010 is the coldest measured, reaching the percentile 10) and that the months of July were relatively warm for both years. This could have favoured the stratification of the surface waters.

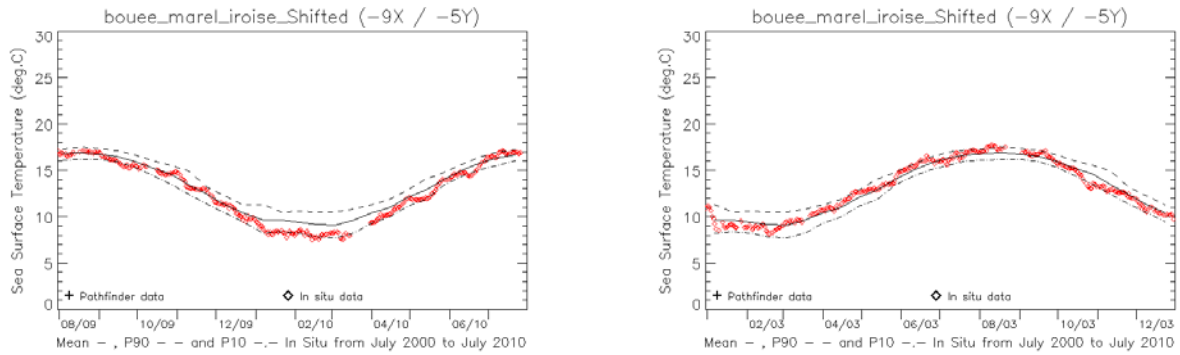


Figure 6: Sea surface Temperature at the Marel Iroise buoy (Sainte-Anne du Portzic)

The solar irradiance is also available from satellite data (METEOSAT) and it could contribute useful information although its variations are quite similar to those of the temperature in summer. We could refer to the model proposed by Vanhoutte-Brunier et al. (2008) to fully use this information in future.

The images at Figure 7 show several chlorophyll concentrations maps observed from July 10th to August 3rd 2003. After July 22nd the bloom progressed easterly in several days, giving the unusual feature of August 3rd characterised by high chlorophyll concentration at a place (north-west of Normandy) where it seldom occurs at such a level. We know from a July 2003 CEFAS seawater sample (Vanhoutte-Brunier et al., 2008) that the bloom was initially dominated by *K. mikimotoi*. Was it still the case at the end of July and in August? What we know is that *K. mikimotoi* was still present in the first half of August as it was observed from water samples collected by the Ifremer Station of Dinard north-east of the Baie de Saint-Brieuc, and that after that fishermen reported dead fish at the surface of the water.

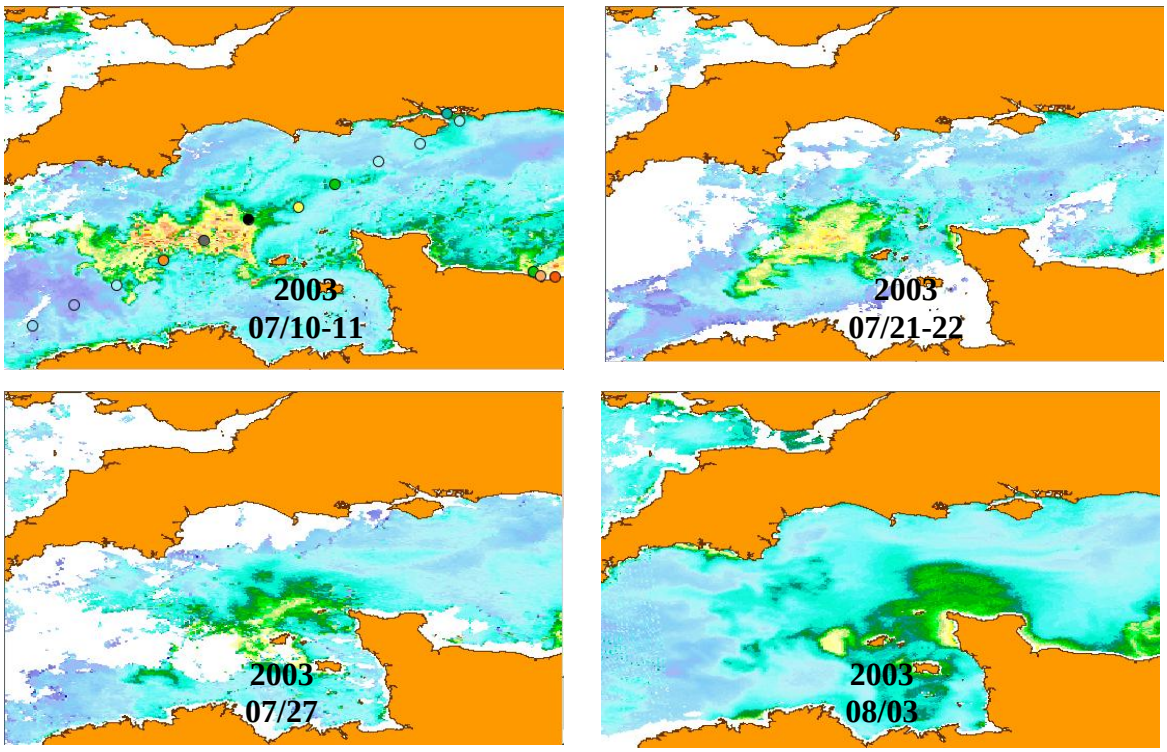


Figure 7: Evolution of the 2003 bloom (SeaWiFs and Modis)
Chlorophyll concentration derived from fluorescence measured from onboard a ferry (Courtesy of the Southampton Oceanography Centre) are also shown on the 07/10-11 image.

Conclusion

Once more a *K. mikimotoi* bloom has been observed in the western English Channel after a sunny and hot episode. It is not a new phenomenon (Miller et al., 2006, Vanhoutte-Brunier et al., 2006) but, this time, the alert has been set in Near Real Time to users registered to the Ifremer/Marcoast server of images. They were informed that a strong phytopklankton bloom, probably of *K. mikimotoi*, was approaching the coasts of Guernsey. The Fisheries Department of the States of Guernsey Government informed the Environmental Health and Pollution Regulation Unit. Samples of water were then collected very quickly in the area of the bloom (July 22th). The analysis at CEFAS Lowestoft showed a very high concentration of dinoflagellates, mainly *K. mikimotoi* but also *Dinophysis* species. The weather forecast at the end of July was not favourable to the bloom and a rapid decay was expected. In fact the decay was very progressive and the bloom was still visible, West and South-West of Guernsey, around August 10th but no damage has been yet reported. The conclusion of this experience is that it is now possible to identify a *K. mikimotoi* bloom in the Western English Channel in Near Real Time from space as it appears that this species finds in this marine environment the optimal conditions for its development while inhibiting competitors by its toxin (Gentien et al., 2007). Rapid exchanges between satellite data providers for the area (PML and Ifremer for MyOcean/MarCoast) and people in charge of the surveillance of the water quality have permitted the formal identification of the species responsible for the bloom observed on the satellite images. As the weather forecast (lower temperature, wind, cloudy sky) weren't favourable for the development of *K. mikimotoi*, a decay of the bloom was expected. This

decay appeared to be relatively slow but no damage has been reported. Although it is not possible to fight such a bloom, the knowledge that we have gained from all the observations and analyses (modelling) of these last years will permit a good forecasting and understanding of this HAB when the conditions (sunny sky, low wind and hot temperature) are gathered at the beginning of summer. This is also the aim of the ASIMUTH (HAB) and COBIOS (high biomass blooms) projects (FP7 GMES downstream).

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