Use of satellite imagery to complement the monitoring of Harmful Algal Blooms and Eutrophication to support marine management.

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In 2016, bathing water off the coast of Hampshire and Dorset became discoloured and foam was sighted by tourists. Light brown and white foam was also seen in Langstone Harbour. This coincided with Cornish shellfish mussel famers being unable to harvest during five months. In 2015 mussels farms were shut for four months.

The discolouration of the water and the shellfish harvest ban were because of Harmful Algal Blooms (HABs). Algal blooms are the result of the rapid growth of phytoplankton, which can occur in both freshwater and marine water systems. A number of physical, chemical and / or biological factors can trigger these events, such as: sunlight, warm temperatures, salinity, rainfall, and increases in nutrients through human activities such as agricultural or household run-off.

These algal blooms become harmful when the phytoplankton release toxins which then accumulate in shellfish , either directly from the water or through organisms that shellfish eat. The toxins can then be transferred up the food chain, to crustaceans, birds and marine mammal. Humans can suffer different types of shellfish poisoning depending on the toxin that is consumed. Impacts on human health in the UK can range from nausea and vomiting, to more severe symptoms including gastric problems and amnesia.

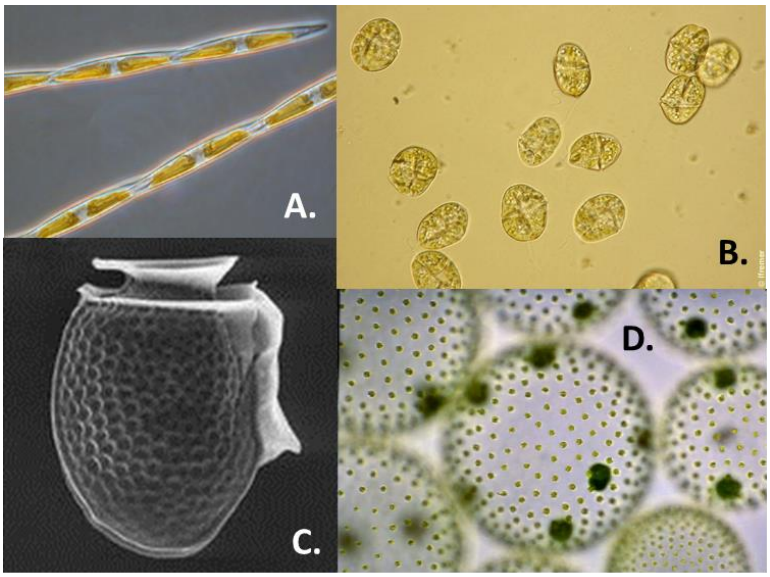

Figure 1. Harmful Algae that occur in the English-French Channel; A.) *Pseudo-nitzschia sp.,* B.) *Karenia mikimotoi,* C.) *Dinophysis spp.,* D.) *Phaeocystis globosa.*

Non-toxic algal blooms can also impact the environment by lowering the oxygen level in the water column, which is known as hypoxia. Such hypoxic events can lead to higher mortality of both wild and farmed fish, shellfish and other marine organisms. These non-toxic HABs can also cause fish mortality by clogging or irritating their gills of fish and shellfish leading to suffocation.

HABs can lead to the closure of fishing and shellfish harvesting areas for many weeks and in some cases months resulting in significant economic losses. If harvested shellfish are found to contain above a threshold level of the toxins, they are stopped from being sold. In 2015, on California's North Coast the Dungeness crab fishery remained closed from the 1st December until mid-May due to a yearlong release of the phytoplankton toxin domoic acid.

HABs not only impact fisheries and human health. They also can have negative effects on tourism and recreational activities. The occurrence of HABs can affect activities such as sea angling, recreational shell fishing and scuba diving. This can have knock on effects through tourists choosing different destinations not affected by HABs which can cause economic loss to restaurant and hotels. The economic effects of such impacts are poorly documented. In the EU, the economic effects of HABs are roughly estimated around $ 813 000 000 (2005 dollars) this figure include losses for public health ($11 000 000), commercial fisheries ($147 000 000), recreation and tourism ($ 637 000 000) and monitoring and management ($ 18 000 000). Predicting the occurrence of HABs is difficult, but due to their impacts, they are closely monitored. Both water and shellfish flesh are sampled and tested on a regular basis. In areas with historic risk of Paralytic Shellfish Poisoning, samples of shellfish are tested fortnightly from April to the end of September. Beyond this period from 31st September to 31st March, testing is conducted monthly. In England and Wales, the Environment Agency and CEFAS () are responsible for coordinating of the monitoring programme on behalf of the FSA (Food Standards Agency), who are ultimately responsible for food safety. In 2017, 906 phytoplankton samples and more than 700 inshore shellfish samples were tested in England and Wales. In 2016 the Environment Agency also took and analysed 11 566 water samples in England between April and September. Despite this extensive monitoring programme, only 3% of the English Channel area is currently monitored for an estimated cost of £2 million annually. In 2016, Channel's ports accounted for 21% by quantity (that is more than 31520 tonnes) and 19% by value (more than £338500) of all landing by UK vessels into the UK.

Scientists are working on improving the monitoring and prediction of HABs using satellite images which can provide a cost effective means of observing HABs over larger spatial and temporal scales to complement current monitoring efforts. A new EU INTERREG France Channel England Programme (FCE) project, launched in 2017, is using the latest satellite technology to improve the way water quality and harmful algal blooms (HABs) are monitored in the English Channel. Lead by Plymouth Marine Laboratory (PML), this four-year project gathers scientists from 8 French and English organisations. The project known as S-3 EUROHAB will use data from the recently launched European satellite, Copernicus

Sentinel 3, to track the growth and spread of certain HABs and phytoplankton abundance related to water quality, in the French-English Channel. The satellite data will then be used to trial a web based alert system, to inform marine managers and fishing industries of the growth of potentially damaging algal blooms. Data will also be gathered to help better understand why, how and when HABs occur.

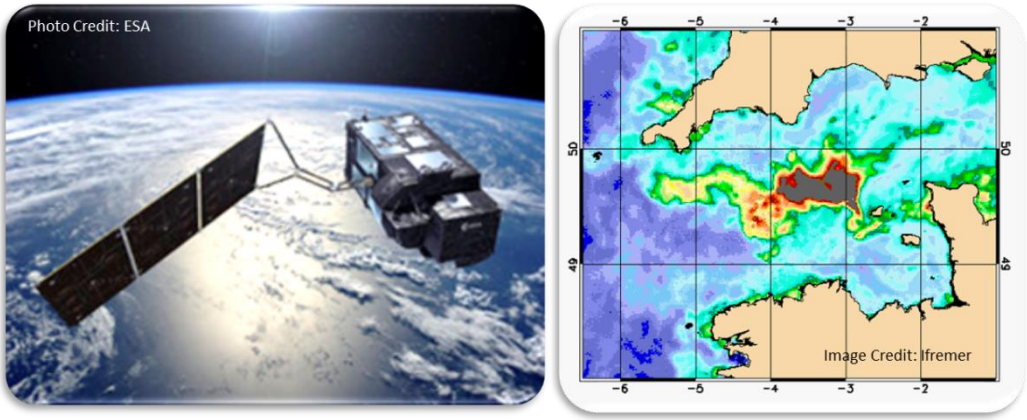

Figure 2. *Left hand side; the latest European Space Agency satellite mission Sentinel-3 that is designed to observe a suite of oceanographic parameters from space including satellite blooms. Right hand side; Satellite image of a harmful algal bloom (red-orange-grey colouration) in the English Channel.*

In addition, the project will work with stakeholders to assess the socio-economic impacts of HABs. It will identify who is impacted by HABs, how HABs impact their activities or practices and what are the costs associated with these impacts. These outputs will provide a clearer indication of the economic costs of HABs to the Channel region as well as the potential savings that can be made through the use of the web alert system.

To find out more about S-3 EUROHAB or offer feedback on our activities, please visit our website: https://www.s3eurohab.eu/