Forecasting Harmful Algal Blooms for fish and shellfish farmers
The ASIMUTH project

Context of the project – Harmful Algal Blooms (HABs)

About 300 different types of algal blooms exist – such as phytoplankton blooms, micro-algal blooms, toxic algae, red tides. A quarter of these blooms is known to produce toxins and is referred to by the scientific community as being Harmful Algal Blooms (HABs).

HABs occur when colonies of algae, which can be defined as simple plants that live in the sea and freshwater, grow extensively and produce toxic or harmful effects on their environment (humans, fish, shellfish, etc.). They mostly occur when water temperatures are high and when the water contains nutrients such as nitrogen and phosphorus, depend on ocean currents, surf conditions, and wind speed and direction. They can appear in marine, estuarine and fresh waters as well as along coastlines and surface waters.

HABs can have significant negative impacts on their environment: they can make shellfish and fish toxic, cause massive farmed fish kills throughout Europe and human illnesses. As an example, one single toxic bloom caused the loss of 500,000 salmon in Shetland, an archipelago in Scotland. Such incidents are sporadic and largely unpredictable. Studies have reported that approximately 6% of harmful algal blooms may cause fish mortality. Scientific researchers distinguish two main types of HABs: toxin producers, which can contaminate seafood or kill fish on one hand, and the high biomass producers which can be responsible for an absence of oxygen and important kills of marine life.

Being a natural event, HABs cannot be prevented. But understanding the occurrence and movement of Toxic Algal Blooms is a key commercial / economic factor in marine aquaculture enterprises and in the context of several leisure activities linked to tourism. Better anticipating and monitoring the occurrence of HABs could potentially lead to many cost saving.

Indeed, with 1.25 million of fish or finfish being produced every year, the EU is the 8th biggest producer in terms of volume of aquaculture in the world, with the top 7 aquaculture species being: Mussel, Trout Salmon, Oyster, Carp, Sea Bream and Sea Bass. With 85,000 people directly employed in the European aquaculture sector, marine aquaculture is practiced in every coastal member state of the EU. The figure highlights the growing important of the aquaculture industry in Europe. Most of the increase can be explained by the significant production of salmon over the past decade. All these elements underline the importance of establishing an effective and reliable HAB monitoring system throughout Europe.

The ASIMUTH project: HABs forecasts based on Copernicus

In this context, the “ASIMUTH” project (Applied Simulations and Integrated Modelling for the Understanding of Toxic and Harmful Algal Blooms) has been set up in order to respond to the demand for short-term forecasts of harmful algal blooms events along the European Atlantic coast, using EO data.

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The ASIMUTH project brings together a European consortium of 11 scientific institutions and businesses mixing research institutions (such as the Irish Marine Institute and the French IFREMER) and companies (including Starlab, a Spanish-based company providing value adding services based on EO data, and Hocer SAS, a French company developing and producing water analysis systems for the protection of all drinking water resources.

The project tracks the origins of algal blooms using remote sensing satellite data and monitoring images of chlorophyll and water temperature. The project downscales the products of the Copernicus Marine Environment Service (CMEMS) and integrates these products with biological data with input from HABs experts to produce warning bulletins to aquaculture producers. The products are delivered in the internet and on mobile devices and allow customers to make viable commercial plans to reduce the commercial impact of these blooms.

The project initially started in 2009 with a series of initial steps comprising a series of technical and scientific objectives which enabled the modelling of physical and biological interactions leading to the forecasting of toxin events, fish mortalities or ecological disruption from HABs. The partners of the consortium worked together in order to address shared problems.

The different scientific aspects of ASIMUTH can be summarised as:

- The identification of key past events which were re-analysed and used to test the modelling system
- The incorporation of the Copernicus Marine Core Service (CMCS) with the key past events identified and used to develop model based hindcast products in order to make the model more operational and efficient to forecast events
- The designation of regional model systems and delivery of nowcasts for specific HABs and location information, transport pathways, remote sensed data.
- An indication of the population of HAB-distributed decision support system from various data streams (such as phytoplankton, biotoxin, satellite, etc.)
- Provision of experts’ interpretation of the available data by way of the web portal which was carried out on a periodic basis depending on risk.

The CMEMS is a cornerstone to the project: it is absolutely necessary to obtain very accurate and real-time data in order for the experts to build accurate HABs forecasts. There currently is an unprecedented flow of information on the European ocean from the Marine Core Service (MyOcean) using mechanisms such as Model Forecast Centres (MFCs) and Thematic Assembly Centres (TACs) distributed throughout Europe. Furthermore, ASIMUTH is the first project to operationalize elements that were before solely research elements.

**Copernicus enabled revenues for fish and shellfish farmers**

HABs caused the closing of bays for harvesting and left farmers to wait until the bay re-opened. These closures could last for several months, causing extensive production losses. Thanks to the ASIMUTH project, a...
A forecasting system for HABs in the European Atlantic was developed, as well as innovative models and strategies to improve sustainable utilisation of fish and shellfish, by integrating a wide range of data to understand the functioning of algal bloom movements.

The ASIMUTH project has had sound economic impacts: the provision of accurate HABs forecasts has enabled fish farmers to increase their productivity by approximately 5%, by optimising harvesting schedules and installing appropriate aeration systems. Indeed, an early warning system for blooms gives producers the chance to change their practices by installing oxygenation systems, moving their stocks, harvesting their fish earlier, etc.

More specifically, the forecasting system implemented within the ASIMUTH projects targets to reduce the losses caused to the mussel industry by at least 12.50% in five target countries: France, Spain, the UK, Ireland and Portugal. According to an analysis performed by the ASIMUTH consortium (see Figure below), the average total losses in the mussel industry in these countries amounts to USD 20,745 million (i.e. EUR 18,290 million). Considering that the 12.50% of savings are reached thanks to the ASIMUTH project, it would represent a potential saving of USD 2,593 million (i.e. EUR 2,292 million).

<table>
<thead>
<tr>
<th>Country</th>
<th>Average Total Losses due to HABs ($)</th>
<th>Potential Savings due to ASIMUTH if 12.5% of losses are recouped ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td>9,556,919</td>
<td>1,152,029</td>
</tr>
<tr>
<td>Spain</td>
<td>6,320,046</td>
<td>758,718</td>
</tr>
<tr>
<td>UK</td>
<td>2,658,419</td>
<td>337,535</td>
</tr>
<tr>
<td>Ireland</td>
<td>2,197,607</td>
<td>284,091</td>
</tr>
<tr>
<td>Portugal</td>
<td>12,179</td>
<td>1,616</td>
</tr>
<tr>
<td>TOTAL</td>
<td>20,745,170</td>
<td>2,593,146</td>
</tr>
</tbody>
</table>

Figure 4 - Value of savings due to ASIMUTH for the mussel industry (Source: ASIMUTH consortium)

Before the implementation of the project, HABs caused the mortality of 8,000 tons of fish per year (corresponding to EUR 31.3 million) and extensive losses from the fish farms. Today, the forecasting system is considered as being close to 100% in terms of accuracy, and is expected to improve continuously thanks to perpetual improvement of the accuracy of the system, meaning that it should prevent the loss of a significant amount of fish. Indeed, the early warning of severe HABs has allowed fish and shellfish farmers to adapt their culture and harvesting practices in time in order to prevent potential losses due to contaminated fish. On the longer term, a more adapted and efficient harvesting strategy has allowed fish farmers to increase their productivity.

According to the FAO, the demand for fish consumption is expected to grow substantially – it should rise by 30% between 2010 and 2030. Hence, in order to face this increasing demand, the five target countries need to build reliable and sustainable fish farming strategies in order to face any upcoming challenges. The ASIMUTH project additionally aims at providing the necessary tools, on the mid to long term, for the fish farmers to respond accurately to this demand.

In addition, a performant HAB monitoring system would enable fish farmers to limit wasting shellfish that contain toxins since specific regulations prohibit the right for fish farmers to sell them. Indeed, a predicted harmful bloom would avoid fish farmers to harvest their fish in the first place.

Better monitoring HABs reduces production costs of fish farmers through insurance deductibles. Indeed, if the protocols are not in place and mortalities occur, the insurance company refuses to pay. If they are just partially in place, the insurance company pays only 60% of the loss of stock.

Non-monetary benefits thanks to preventing HABs with Copernicus

The production of forecasts has enabled improved management practices within fish farms by providing farmers with vital and key decision making inputs. As an example, by appropriately anticipating the HABs events, farmers can take the appropriate decisions to prevent their fish from suffering from any toxic effects (such as piling their products in advance). The combination of the know-hows and expertise of the different partners of the consortium has allowed them to reach improved management strategies towards
the impact of HABs with a particular focus on the sustainability of wild and farmed finfish and molluscan bivalve fisheries (clams, oysters, scallops, etc.).

In terms of market challenges, the aquaculture sector is increasingly exposed to international competition in the fish and shellfish sector. Competition comes strongly from Asia (China and Japan), South America (more particularly Chile), New Zealand and America (Canada and the US). A combination of increased productivity and improved management practices will boost the supply of fish sustainably and limit price fluctuations for raw material. Thus, fish farmers will be in a better position to tackle international competition which characterizes the aquaculture sector.

The ASIMUTH project also has social impacts. Via its integrated forecasting system, it has enabled fin fish and shellfish farmers to acquire knowledge on the best practices to monitor HABs and to prevent them from being contaminated by toxins. Hence, the fish harvested is of better quality and has better nutritional intakes which translate into positive impacts on public health.

This monitoring and forecasting system for HABs can also have positive impacts for other end users than shellfish and fin fish farmers. Indeed, better monitoring HABs can also lead to preventing potential negative impacts on activities linked to tourism. Some HABs can cause foams which float in the ocean that can end up on beaches, which may be very unsightly in tourist spots. By better anticipating HAB, the appropriate authorities can minimize the impact of such events on tourist activities.