ShellEye

Satellite monitoring for early warning of environmental risks to aquaculture farms

Stakeholder Workshop
23rd March 2017
Plymouth Marine Laboratory

PML | Plymouth Marine Laboratory

Cefas

UNIVERSITY OF EXETER

THE NATIONAL LOBSTER HATCHERY

SAMS


Image credit: BBSRC

Introduction to ShellEye

ShellEye is a UK research project that is developing satellite Earth observation (EO) and simple modelling tools for monitoring and forecasting water quality for shellfish aquaculture. These tools will help shellfish farmers make more informed decisions for harvesting, stock control and mitigation against reduced water quality thus contributing to safeguarding human health and the development of the UK's shellfish industry.

ShellEye has been funded in two stages, each two years in duration. Phase one started in May 2015, phase two started on 1st January 2017.

Progress during phase 1

- Developed techniques to identify potentially harmful algal species in satellite images to improve detection of future Harmful Algal Blooms (HABs).
- Analysed in situ water samples to validate our data and investigated the opportunities offered by other satellite products.
- Combined ocean measurements with meteorological and earth observation data to create early warning indicators of microbiological hazards and biotoxin levels.
- Worked with farmers to develop and test a bulletin service to provide relevant, near real-time information directly in a cost-effective and accessible way.

ShellEye will continue this success in phase 1 by...

- Expanding the range of organisations that we are working with to involve more aquaculture farms in more areas to ensure maximum exploitation of the potential benefits of ShellEye's approach.
- Enhance the precision of near-coast and near-farm HAB risk estimation.
- Develop long-term HAB probability maps to assist in insurance risk assessment and site selection.
- Test the value of our service for other types of aquaculture, including finfish and lobster, and exploit new satellite sensors and enhance monitoring capabilities.

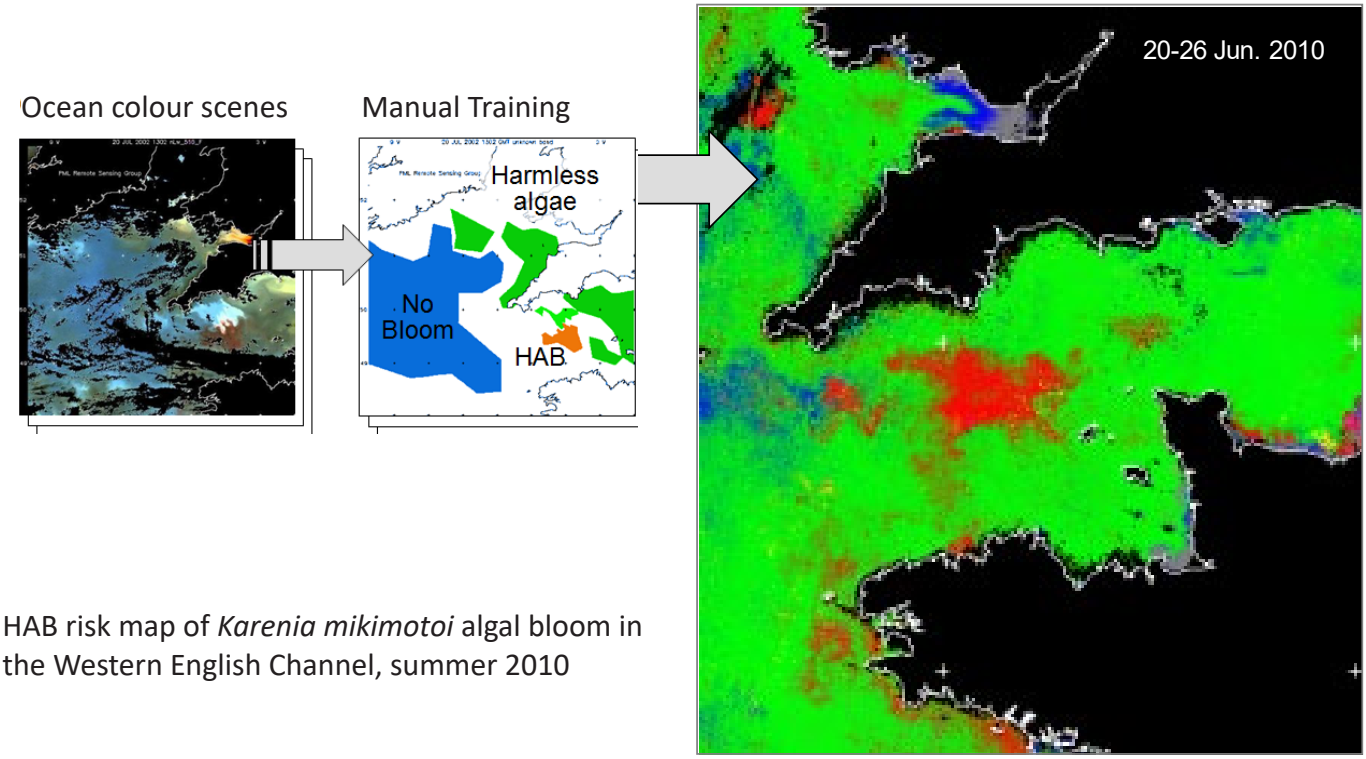
Purpose and format of the workshop and this report

To create a useful and viable service for farmers, ShellEye researchers need to understand the factors which affect water quality and the impacts on the shellfish industry. Also needed is feedback on the project and bulletin service as it is developed. This feedback is crucial at this mid-point stage of the project in order to develop and improve the bulletin service and tailor it to the needs of farmers.

A workshop was organised at Plymouth Marine Laboratory (PML) to bring together stakeholders (farmers, insurance industry, relevant associations etc.) with project staff to discuss the project and gather valuable insight and feedback. During the workshop the participants were divided into 3 groups of 6 people for in depth discussions on key aspects of the ShellEye project. The different stakeholders and project staff were spread out among the groups to ensure balanced discussions.

This report provides an account of the meeting. As well as providing an overview of information presented by ShellEye project staff, it is a record of the points and concerns raised by the stakeholders in attendance so that, where appropriate, the project can learn from these insights and perspectives

Identification of Harmful Algal Blooms (HABs)



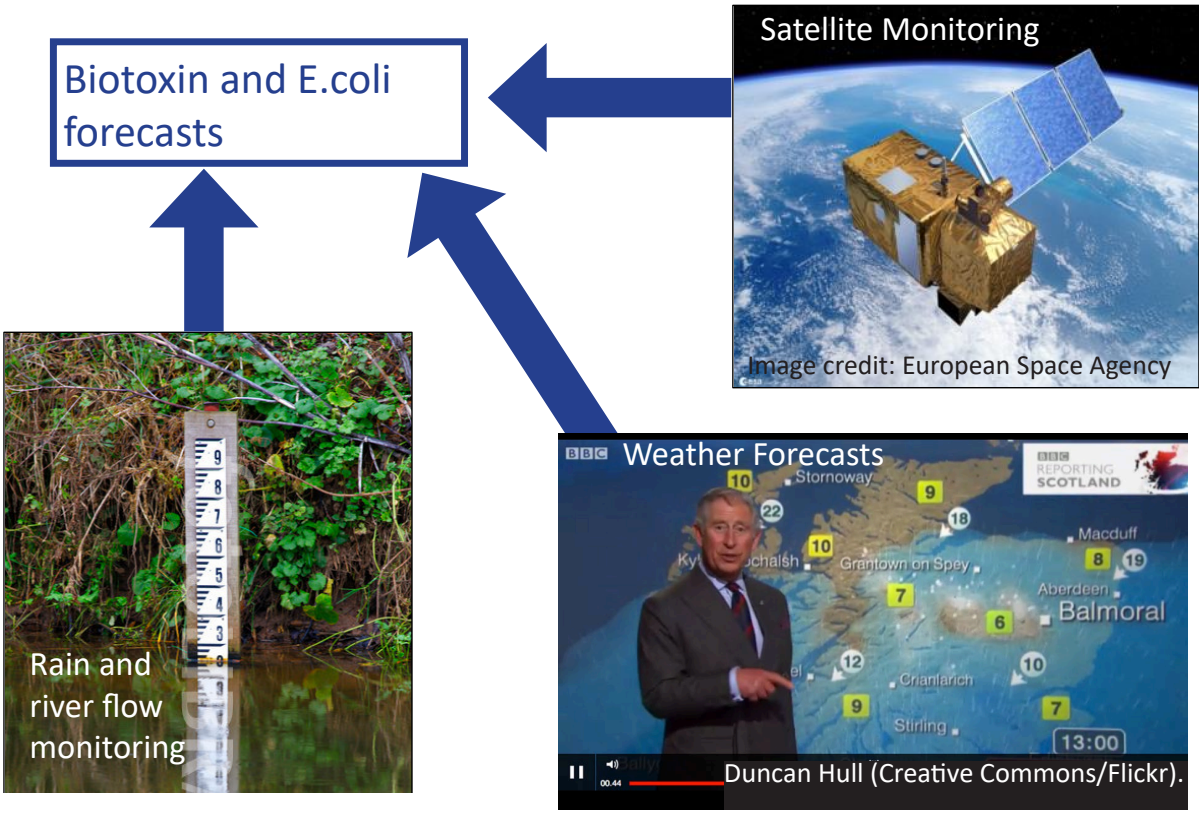
HAB risk map of *Karenia mikimotoi* algal bloom in the Western English Channel, summer 2010

- HAB risk - harmless - no bloom - not classified

The ocean has many different colours depending on the amount and type of sediment and plankton it contains. Satellite images of the earth can provide a visual of these colours across the globe. Researchers use these images to translate the colours into numbers to give us information about what is in the water, such as the species and concentration of algae.

Certain species of algae release natural toxins, which can build up in shellfish flesh, particularly when there are large blooms. If the flesh is then consumed these toxins can be harmful to humans. ShellEye is developing a classifier that can identify HABs. By monitoring the abundance and distribution of harmful algae ShellEye can provide farmers with an early warning of whether the blooms are likely to affect their farm.

Short term forecasting of biotoxin and E. coli conditions

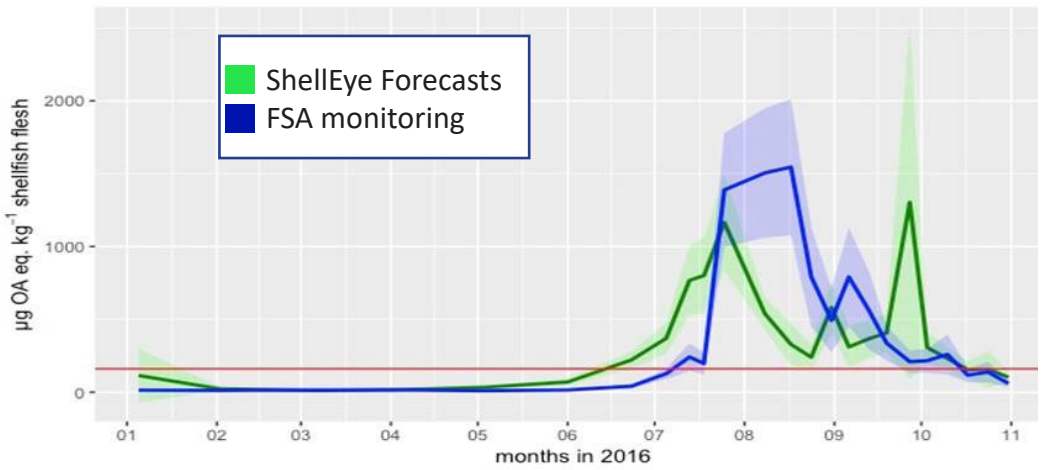


Levels of biotoxins and e.coli are forecasted for the week ahead by combining satellite, rain and river flow monitoring with local weather forecasts. Biotoxins and e.coli forecast models were developed using historical Food Standards Agency (FSA) monitoring data. The graph below shows the forecasts and the FSA data for a farm site in 2016. Forecasts are also checked against results from in situ sampling.

The graph below shows the group biotoxin levels (blue line) of okadaic acid (OA)/ dinophysistoxins (DTX) and Pectenotoxins (PTX) which can be produced by the dinoflagellates Dinophysis spp.. The displayed biotoxin concentrations were measured by the FSA at our test farm site during 2016 and the blue shade displays the minimum and maximum of measured levels.

The green line shows our equivalent model predictions of the biotoxin levels, based on the environmental conditions in which the mussel was living. The green shade shows the confidence range of the model prediction.

The model was able to provide a warning of the increase in biotoxin levels (i.e. the point at which the blue line crosses the permitted limit of 160 ug OA eq. per kg shellfish flesh) in advance of the measured toxin results showing an increase. This early warning of a change in biotoxin levels can be used by the farmer to support farm management.



The Y-axis displays the concentration of the group biotoxin levels (in micrograms okadaic acid equivalents per kilogram shellfish flesh).
Red line is the maximum permitted limit of 160 ug OA eq. per kg shellfish flesh. Levels over this maximum mean that the farm is closed to harvesting until the levels fall

Early warning bulletin for shellfish and finfish farmers

A water quality monitoring and forecast bulletin for shellfish farmers is then constructed using the satellite monitoring and short term forecasts of the water quality around the farm.

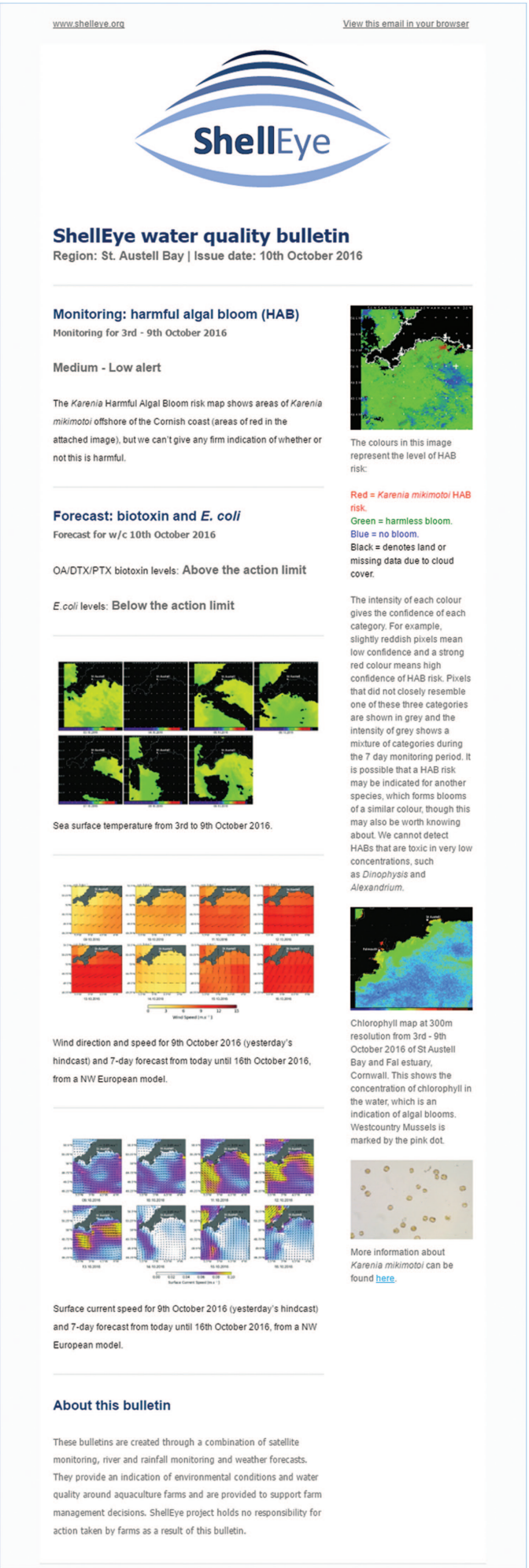
The bulletin provides the farmer with an indication of the water quality around their farm and how the quality may change over the next week, allowing them to use this information to support farm management decisions. This could include harvesting early or increasing the length of any depuration process to avoid a potential stock recall.

The pilot bulletin service, developed throughout phase one of the project, includes the current alert levels for biotoxins and E.coli alongside a map of the area indicating the current position of any identified HABs in the region of the farm.

The bulletin also provides key environmental information including:

- Sea Surface Temperature maps for the preceding week.
- Wind direction and speed map for the previous day (hindcast) and 7 day forecast.
- Surface current speed for the previous day (hindcast) and 7 day forecast.
- Chlorophyll map at 300m resolution for the preceding week for the area indicating the concentration of chlorophyll in the water, which is an indication of algal blooms.

A key activity during phase two of ShellEye is to improve and extend the bulletin content and the interpretation of information to ensure it meets the needs of farmers. We are very keen to hear farmers views on the format, content and accessibility of the bulletin as well as the frequency at which it should be provided and whether farmers would be willing to pay for this service in order to ensure it is sustainable after project funding has ended.



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ShellEye

ShellEye water quality bulletin

Region: St. Austell Bay | Issue date: 10th October 2016

Monitoring: harmful algal bloom (HAB)

Monitoring for 3rd - 9th October 2016

Medium - Low alert

The *Karenia* Harmful Algal Bloom risk map shows areas of *Karenia mikimotoi* offshore of the Cornish coast (areas of red in the attached image), but we can't give any firm indication of whether or not this is harmful.

Forecast: biotoxin and *E. coli*

Forecast for w/c 10th October 2016

OA/DTX/PTX biotoxin levels: Above the action limit

E.coli levels: Below the action limit

Sea surface temperature from 3rd to 9th October 2016.

Wind direction and speed for 9th October 2016 (yesterday's hindcast) and 7-day forecast from today until 16th October 2016, from a NW European model.

Surface current speed for 9th October 2016 (yesterday's hindcast) and 7-day forecast from today until 16th October 2016, from a NW European model.

About this bulletin

These bulletins are created through a combination of satellite monitoring, river and rainfall monitoring and weather forecasts. They provide an indication of environmental conditions and water quality around aquaculture farms and are provided to support farm management decisions. ShellEye project holds no responsibility for action taken by farms as a result of this bulletin.

The colours in this image represent the level of HAB risk:

Red = *Karenia mikimotoi* HAB risk.
Green = harmless bloom.
Blue = no bloom.
Black = denotes land or missing data due to cloud cover.

The intensity of each colour gives the confidence of each category. For example, slightly reddish pixels mean low confidence and a strong red colour means high confidence of HAB risk. Pixels that did not closely resemble one of these three categories are shown in grey and the intensity of grey shows a mixture of categories during the 7 day monitoring period. It is possible that a HAB risk may be indicated for another species, which forms blooms of a similar colour, though this may also be worth knowing about. We cannot detect HABs that are toxic in very low concentrations, such as *Dinophysis* and *Alexandrium*.

Chlorophyll map at 300m resolution from 3rd - 9th October 2016 of St Austell Bay and Fal estuary, Cornwall. This shows the concentration of chlorophyll in the water, which is an indication of algal blooms. Westcountry Mussels is marked by the pink dot.

More information about *Karenia mikimotoi* can be found here.

General comments and discussion points raised

These are the individual opinions of stakeholders and do not necessarily reflect the views of the ShellEye project team. *Responses from the project team are shown in italics.*

- The accuracy of the *E.coli* model should be tested in a site with higher levels of contamination.
- Some people in the industry are sceptical of the classification system and don't agree it is fit for purpose.
- High *E.coli* results are presumed to be false by some farmers that are not confident in the classification system. Have had cases where farms were closed or classification lowered due to a lab error or unproven result, hence the affected farmers are very sceptical of the current system.
- Each farm / region appears to have its own unique set of biological risks. Some areas experience regular *E.coli* episodes and no HABs for decades whereas other areas experience annual HABs but little impact from *E.coli* and norovirus.
- Example from Ireland where they harvest before Oct-Nov as learnt the hard way after a positive test for norovirus in shellfish flesh caused an expensive recall.

  Response: We are looking at how the service can be useful in highlighting trends in water quality that may give an indication of classification, which could be used by farmers to increase depuration times. The link to classification is more to do with how best to convey the information rather than modelling; the model is not influenced by the regulation.

  Our understanding of the factors influencing microbiological and toxin-producing phytoplankton in coastal waters has grown substantially in recent years. In the first phase of this project, we studied these factors in a coastal embayment impacted by low levels of pollution. Different sites have different impacts and we need to understand impacts in sites with higher levels of pollution. We are already discussing how we will refine the service to account for variability within each site but more data are needed to understand these variations properly. The developed tools cannot be used to predict E.coli concentrations at particular points within a farm but can signpost an increase or decrease in risk to an area.

- Can see potential for model to be used to protect classification from lab errors, for example, if there is a spike in sampling levels the model could be checked to see if there is any basis for the anomaly. This would be a benefit to farmers.
- Why limiting to aquaculture? Scallop harvesting (wild fisheries) could benefit?

  Response: Hadn't considered scallop harvesting but could be supported, would need to investigate further (explored further in discussion session 2, group 1).

- Scotland and Shetland are more collaborative in their aquaculture approach. England is generally more competitive.
- EU is reviewing changes to all official controls on live bivalves. If EU decide to use a full cost recovery system it will be catastrophic for the industry as it will make it too expensive. The EU won't make a decision until spring 2019 (after Brexit negotiations). Industry has accepted that they will need to take on some of the official control costs.
- Products being exported will have to comply but want to see lesser requirements for UK sold products.

Discussion 1: The ShellEye Bulletin Service - key findings

These are the individual opinions of stakeholders and do not necessarily reflect the views of the ShellEye project team. *Responses from the project team are in italics.*

Group 1

- Statements indicating an alert level on the bulletin are helpful
- Would like to see a 5 tier traffic light system and zoomed in versions of the map to focus more on individual farms.
- Introduction section would be useful to provide an interpretation of the results tailored for each area.
- Concerned that farmers could be prosecuted if they had warning but did not react and people became ill

  Response: Bulletin provides an indication of environmental conditions and water quality around aquaculture farms to support farm management decisions, they are not legally binding.
- Concerned that farmers could use information about each other's farms in competitive way, e.g. informing buyers that the farm has received a high alert level. The bulletin may need to be tailored not just to focus maps but also to avoid others seeing the information for your area.

  Response: levels indicated cover the area, e.g. whole bay, and can't be pinpointed to particular farms so if there are multiple farms within a bay they would all receive the same information. Could avoid information about other areas / bays from being included but would have to be a tailored bulletin service for each area, which would require more processing effort and would therefore incur higher costs.

  Experience from Scottish salmon farms is that the farmers use information about other areas to determine what might happen locally, e.g. whether a HAB could affect them in subsequent days. The farmers there don't use the information against each other. Tend to find that if one farm has a warning or makes someone ill it gives a bad reputation to all of the farms in the area so using the information in a competitive way could easily backfire.
- Biotoxins would be the highest priority / of more interest to most farmers, as opposed to HABs. *E.coli* would be of less interest unless the model could be used to support the restructure of the classification system
  or to identify large and sudden changes in levels.
- Expect there would be a willingness to pay for a service, particularly for biotoxin information but very dependent on cost savings on testing measures.
- The markets farms sell to and the processing is very different. In the Menai Straits 90% of the mussels are exported to Holland and are depurated there. In small farms in the Southwest, such as on estuaries, the farmers sell small volumes into niche market places.

Discussion 1: The ShellEye Bulletin Service - key findings

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Group 2

E coli prediction:

- Does it vary smoothly enough for this to be useful, or is there nothing then a storm causes a big spike?
- Time chart will be useful
- What is the frequency/periodicity of predictions? Daily for met data and ocean/met models.
- An alert that "Risks are increasing" would be useful for depuration and end-product testing.
- Most oyster farms are small scale.
- Like the "plume-weighted E coli risk map", as bacteria and virus could be attached to sediments.
- Hard to know how much of plume is related to pollution, e.g. sediments from river vs. runoff from agriculture.

HAB warnings:

- An alert that "Something is coming" would be helpful to fish farmers. Could even auto-start oxygenation systems.
- Building a risk profile would help, then you would know to act if say there is a bloom forming along the coast and there is an easterly wind.
- Are there buoys that can warn about HABs and toxins?

  Response: In the USA buoys are used to provide real-time data on algal blooms, water quality etc.

- Drones could be cost-effective for HAB monitoring. In Vancouver they send out spotter planes. From experience they know where some algae blooms form and they know what conditions are likely to impact on their farms.
- There's many fish kills there, from clogging gills, anoxia, and jellyfish blooms.
- Sunderland Marine Insurance are highly selective in insuring Chilean aquaculture and have reduced their exposure over the last few years.
- There are regular blooms of *Alexandrium* in certain areas of the UK

  Response: unfortunately not usually seen on satellite data.

ShellEye bulletin:

- Wind and currents would be nice to have link to animation of last/next few days. See WindyTY website. Also has significant wave heights.
- How frequent? Some sites are poor at monitoring. Would be best if we gave alerts only when something changes, e.g. the traffic light goes from green to amber.

Image credit: Shutterstock

Group 3

- HABs are a key issue on the south coast of England. Closures are likely over the summer months in this region so would be highly useful to have early warning of such things.
- Many farms are having to change their business strategy so ShellEye could help inform new approaches i.e. harvest earlier, not over the summer etc.
- Longer term trends are definitely of interest.

  Response: With regards to long-term trends, there is little pattern emerging over the past 10-15 years however there are areas that experience a set of conditions that are higher risk.
- Would be useful to get a better understanding of the circulation between the South England and North France coasts. France has already had a *dinophysis* outbreak this year so can events on the northern coast of France be an indicator of what's to come on the South coast of England?
- This service looks like it could provide more interpretation, expert judgement and projections to help inform shellfish farmers' day-today practices as well as long-term goals. Also provided added value above rapid test kits.
- ShellEye could be used to highlight an increase or decrease in risk.
- ShellEye could mean shellfishers do not need as much official testing, especially if set up in collaboration with regulators. ShellEye would be useful as part of a comprehensive monitoring strategy.
- If a farmer subscribed to ShellEye and did not respond to a high alert, would there be repercussions for the farmer?
- More useful to know what's happening in the water rather than the shellfish flesh due to bioaccumulation and low level blooms over winter.
- If farm infrastructure is fixed then currently it can only inform harvest time.
- SST data would be of interest as it would show when spawning may take place.

  Response: ShellEye could look into offering a 3 day SST forecast.
- Would be good to understand the characteristics of individual farms or areas.
- Visualisations of HAB movements and farm closures would be useful; simple, visual, easy to understand straight away.
- Bulletins need to be regular and consistent so users know they are coming and to keep a look out for them.
- Sampling results are made public so there is little commercial sensitivity.
- Email is best with a text to direct users to check their email. Can these be offered in the registration profile preferences?
- Positive response to how the Scotish bulletins are displayed (maps with dots).
- Only send out when something changes so more of an alert. Use the website for full information.

HABs and Insurance, Sunderland Marine Insurance (SMI)

- Sunderland Marine was established in 1882.
- Based in the North East of England.
- Began insuring Aquaculture and Fisheries in 1986.
- One of the largest global insurers of Aquaculture.
- Dedicated Risk Management Team for all clients.
- 'A Stable' Standard and Poor's rating.
- Experience of HABs:
    - A *Chattonella* bloom in Chile in 2016 caused around $800 million of losses including $100 million of insurable losses after El Nino conditions gave rise to significantly increased algal production compared to previous years. A satellite warning system could have reduced losses.
    - In British Columbia algal blooms have become part of the farming cycle. Operators carry our daily samples at the site to identify and quantify the species present with every member of staff able to take samples and identify key species. Monitoring is standard across all farms and there are frequent flights over known seeding areas to assess the situation. All farms have tarpaulin curtains and oxygen systems to militate against the blooms. However, this is not a perfect solution as some farms are still lost.
- Future of monitoring:
    - Farms are getting smarter and services need to mirror this.
    - Need better informed decision-making, so the speed and accuracy of the data is important.
    - Integrated systems are becoming the standard for larger companies.
    - Satellite/camera based bloom monitoring systems are increasing
    - Centralised systems logging and monitoring data
    - Better informed decision making, speed and accuracy of data
    - Companies are looking for the next step as well – what to do to once a bloom has been identified.
- Questions raised:
    - Could the system trigger an automatic response at the site?
    - Species specific warnings?
    - Inshore accuracy?
    - Using historic information for site selection and transport routes?
    - Relationship between algal blooms and jellyfish blooms?

      Response: There may be a link between plankton and jellyfish blooms. Needs further research.
    - Customer buy-in or open access?
    - Can current, weather and nutrient data be added to the risk matrix?


Image credit: Shutterstock - chuckstock

Cefas: role in shellfish monitoring and vision for the future

- Cefas, in conjunction with a range of partner organisations across the UK, works closely with the FSA and local authorities to deliver these official controls:
    - Sanitary surveys
    - Classification and microbiological monitoring of production areas
    - HABS surveillance programmes and monitoring
    - Shellfisheries water quality
- Cefas work with the Environment Agency to ensure that the risks from pipeline discharges and other pollution sources are controlled.
- The management of microbiological and algal toxin hazards in shellfish requires an integrated system of ecosystem models and multi-parameter observations.
- Long-term continuity of satellite and in situ measurements of physical and chemical properties of the waters at fine resolution are required to support operational risk management systems.
- Development of early warning indicators of microbiological hazards:
    - Surface water circulation and turbidity gradients
    - Dilution of effluent discharges
    - *E.coli* in shellfish
    - Physical and chemical properties of the waters.

Comments / discussion points following presentations

- There is a potential link between jellyfish blooms and algal blooms but further investigation needed.
- Transport routes need to be considered as satellite monitoring could inform when to take on water or avoid HABs

  Response: we have some expertise on transport routes to avoid HABs (or blooms in general), similar to ballast-water exchange issue.
- Run-off from farms is still a considerable contaminant with manure spreading responsible for up to half of the bacteria loading downstream.

Discussion 2: Looking to the future

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Group 1

Scallops:

- Can land scallop catch at any port. Responsibility is on the processor to do the testing
- The ShellEye bulletin could inform processor how much testing is needed as long as know where fished from. Each test costs around £200/sample.
- Scallops are slightly different than other shellfish as the toxins don't build up in the flesh part that is consumed, the majority of any toxins found are in the gills. The problem comes if the gills are used to cook with, such as to make a broth. There is therefore an education issue around not using the gills and making scallops safer to consume.
- There is no quota for scallops but fishermen do have to report landings to the Marine Management Organisation (MMO). The accuracy of landings, in terms of area caught, is not specific (i.e by large ICES areas rather than the more defined ICES rectangles).

Stakeholder Engagement:

- *How can we get more farmers engaged in the project and attending these workshops?*
- Comes down to funds as their time is not covered, they are expected to contribute voluntarily while project staff are paid to attend.

  Response: Project staff would be interested in paying for stakeholder's time to attend but face our own challenges as the research is not funded at 100% and the research institutes have to make up the difference from other sources. Often the funding rules do not allow for payments to be made to individuals and there are strict rules on what can be offered. The mechanism to pay for farmers time would be to include them as a partner in the project but to set this up is time consuming and the success rate of proposals could mean that farmers have to dedicate significantly more time to the process than is remunerated.

  The hope is that farmers appreciate that the tools we are working towards could support their business and save them time and money in the long run but it needs their input to ensure they are successful.

  Agreed: Funders need to be much more aware of costs and challenges for academia and industry and provide funding structures that appropriately support both sides to participate.

Bulletins:

- Would prefer to have more complete SST images even if this means some of the data is less accurate as researchers have had to gap-fill to compensate for clouds.
- Could send out a couple of styles of bulletins to farmers and request feedback by email. This could be distributed through associations such as the Shellfish Association of Great Britain.
- The bulletin mustn't be too long
- Frequency: when conditions / risk levels change. Would be good to have access to look at results weekly, such as online, but email bulletins should be sent out when there is a change in conditions.
- The complexity of the bulletin may turn some people off as majority of farmers operate small businesses.

Algal Bloom
Image credit: dreamstime_Boris Panasyuk


ShellEye Project Team

Group 2

Willingness to pay:

- Depends on site, those with lower perceived risk less likely to be willing to pay for a service. However, those that have experienced blooms are more likely to be interested.
- Could be beneficial in various places worldwide, where they take samples for phytoplankton. Sunderland cover most parts of the world apart from Asia. There could be major interest in the project in other countries, e.g. Canada, where there are historical issues with algal blooms and low oxygen on the East and West coast. South of Brunswick to Maine; oxygen crash.
- Oxygenation can be in place for a whole month, costs money. Particularly important when feeding.
- Insure for mortality of stock, for the cost of production, not the commercial value. Some oyster stock insurance.
- We compared individual farms paying vs. industry-wide, a levy on membership fees.
- Favours individual, so can be a competitive factor: 'We use satellites' (cf organic certified, or Norovirus-free).
- Wild fish – different issues?
- How much does it cost us to implement service: model site, visit site, biotoxins, etc. Tens of thousands. So struggle to roll out to new areas.
- Once service is running, SMI will communicate project outcomes to relevant clients.
- Seafish have a Strategic Investment Fund.
- Farmers would happily give up time to take extra measurements we need to improve service, if that lowers their subscription.

Stakeholder Engagement:

- Good shellfish conferences: ASSG, SAGB; Irish Association - smaller.
- There's a new Aquaculture UK conference run by Scottish Aquaculture Innovation Centre (SAIC), normally biennial.

Group 3

- Possible funding:

  1. European Maritime Fisheries Fund (finishes 2020. A similar national fund will have to be split between the devolved administrations)
  2. BBSRC Aquaculture Network, trade associations (i.e. Shellfish Association of GB)
  3. Crown Estate (their interest has dropped in aquaculture and its sustainable development. More focused on licencing and revenue)
  4. Duchy Estate
  5. harbour authorities
  6. councils
  7. consumer food groups
  8. National Competitive Bidding

- A map of marine leaseholders would also be useful.
- 'Buy one, set one free' lobster campaign has been successful.
- ShellEye research will feed into lobster aquaculture projects.
- Would a pay band system work, based on spatial scales or number of products?
- Would like to encourage a more collaborative approach. If one farm falters, others step in to help.

This report is a summary of presentations and discussions held at a stakeholder workshop on 23rd March 2017 at Plymouth Marine Laboratory. Feedback and insights from stakeholders, as documented in this report, will be followed-up during the second phase of the project in order to develop a viable and useful early warning service for aquaculture farmers.

To find out more and sign-up to receive updates on the project please visit our website: www.shelleye.org

If you did not attend the workshop but would like to comment on the content of this report and/or the ShellEye project then please contact us.

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