DLR

esa

living planet symposium | BONN 23–27 May 2022

TAKING THE PULSE OF OUR PLANET FROM SPACE

EUMETSAT ECMWF EUSPA

Early warning of harmful algal blooms using ocean color and Lagrangian particle trajectories

Peter Miller, Junfang Lin, Andrey Kurekin, Bror Jönsson, Michael Bedington

PML | Plymouth Marine Laboratory

25 May 2022

HAB prediction: ocean colour and particle trajectories

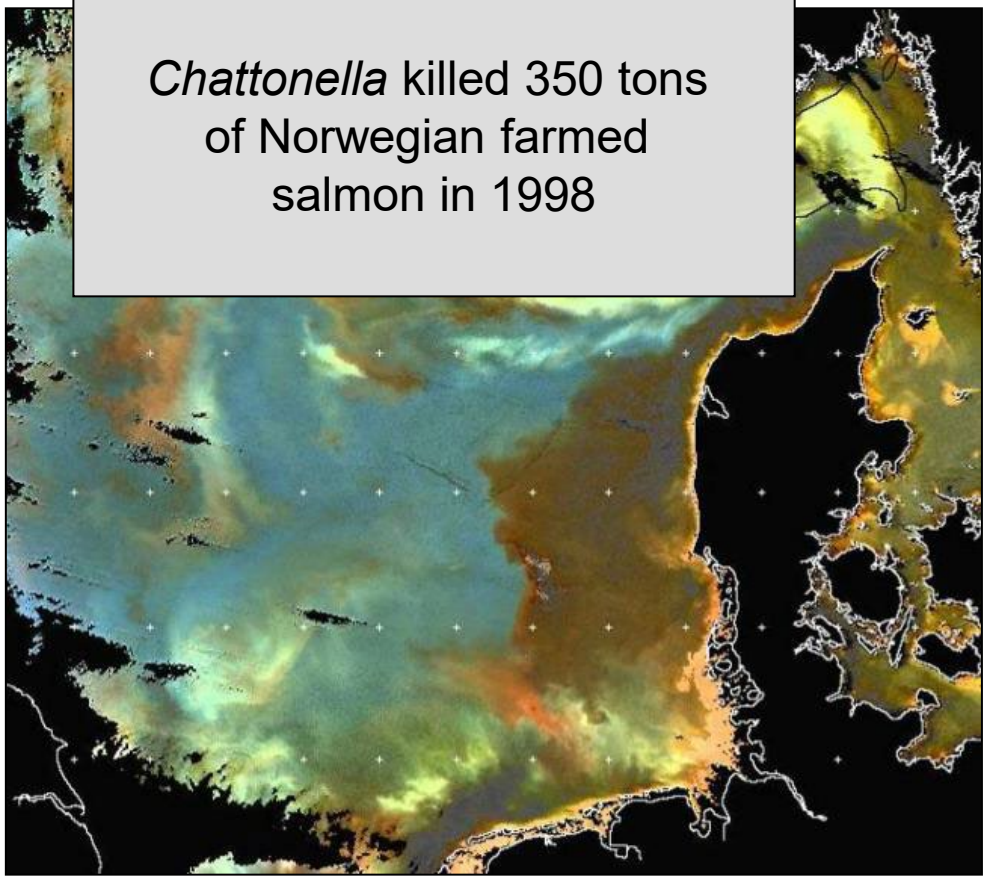
- Ocean colour HAB capabilities
- Merging ocean colour and particle trajectories
- Animations of ocean colour predictions
- Predicting short term HAB risk

PRIMROSE
Predicting the Impact of Regional Scale events on the Aquaculture Sector
Interreg Atlantic Area
European Regional Development Fund
Safe and Sustainable Shellfish
UK AQUACULTURE INITIATIVE
BBSRC bioscience for the future

Examples of harmful algal blooms

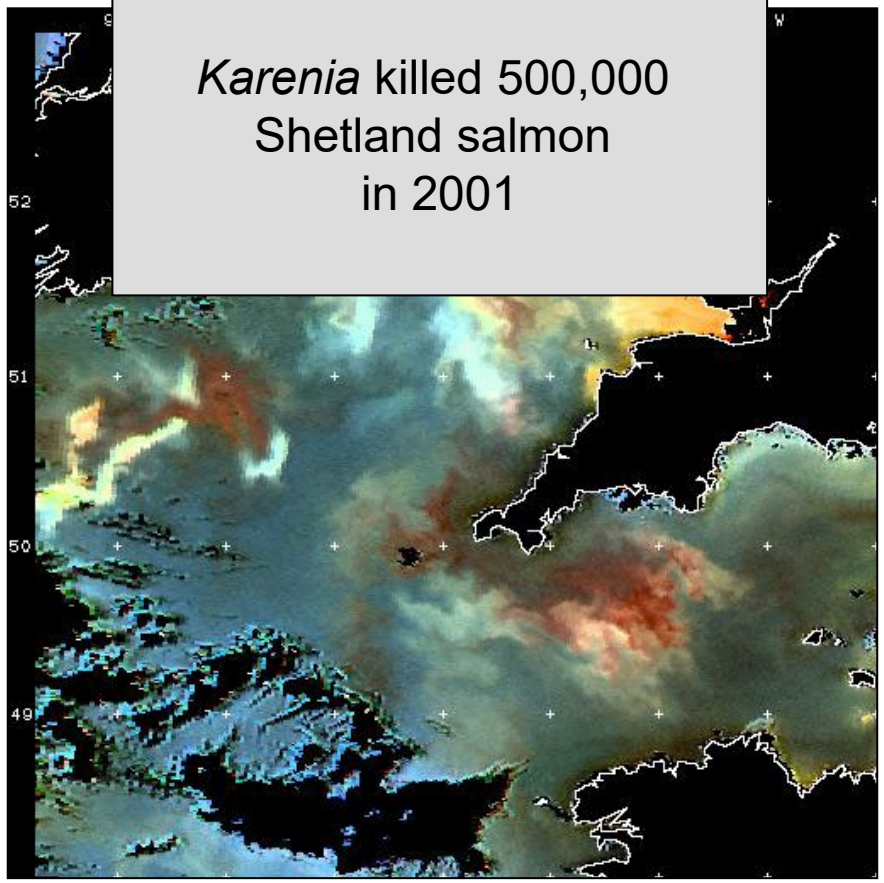
- Early warning for fish farming and aquaculture

Chattonella killed 350 tons of Norwegian farmed salmon in 1998



Chattonella verruculosa in North Sea (11 May 2000)

Karenia killed 500,000 Shetland salmon in 2001

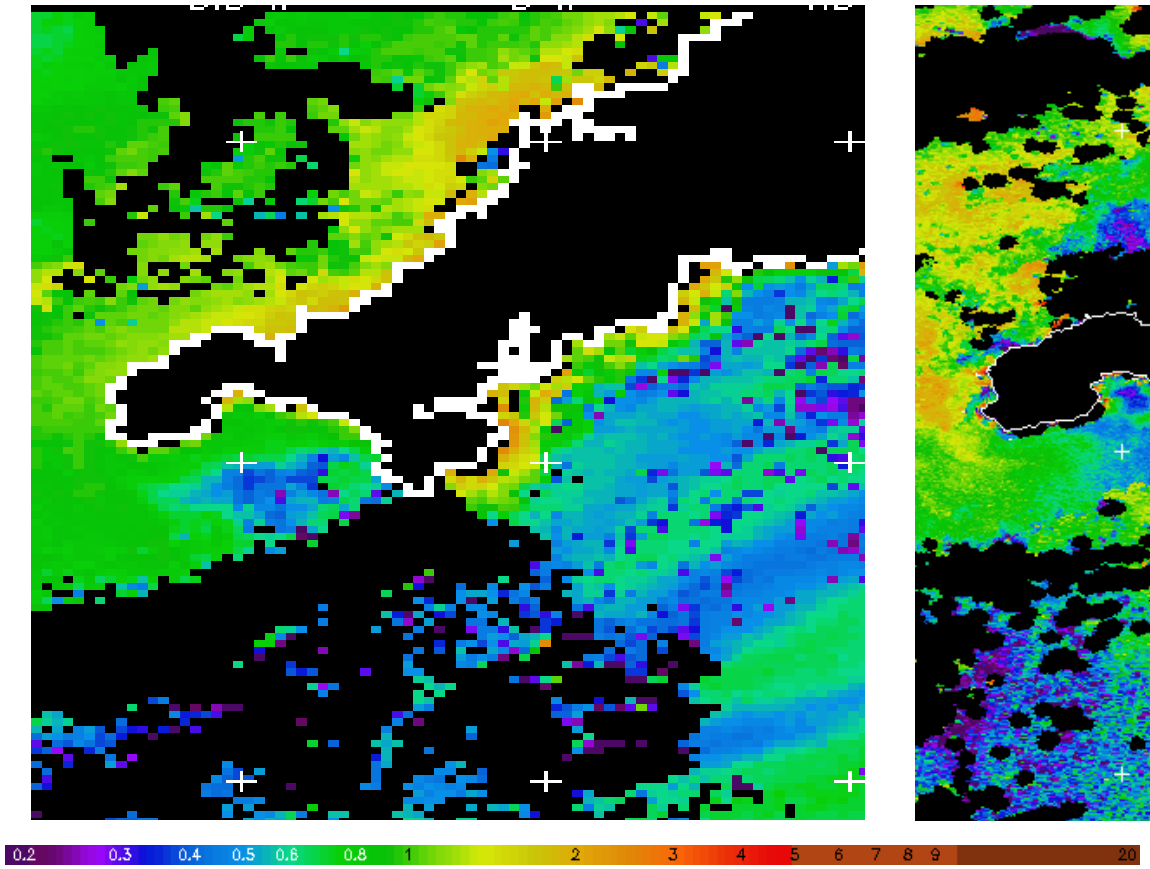


Karenia mikimotoi & *Noctiluca scintillans* in English Channel (20 Jul 2000)

Higher resolution ocean colour

VIIRS 1km resolution

Sentinel-3 OLCI 300m resolution



Chlorophyll-a composite 27 Feb. to 05 Mar. 2018

Capability of ocean colour for HAB warning

Pros

- Operational pair of 300m ocean colour sensors;
- Certain high biomass HABs can be discriminated;
- Clear benefits for finfish farming.

Cons

- Cloud cover and coverage limitations;
- Cannot discriminate key HABs of interest to aquaculture:
  - Species is toxic at low concentration, e.g. *Dinophysis*, *Alexandrium*;
  - No characteristic colouring of bloom.

New approach

- Combine satellite and modelling to overcome limitations.

HAB prediction: ocean colour and particle trajectories

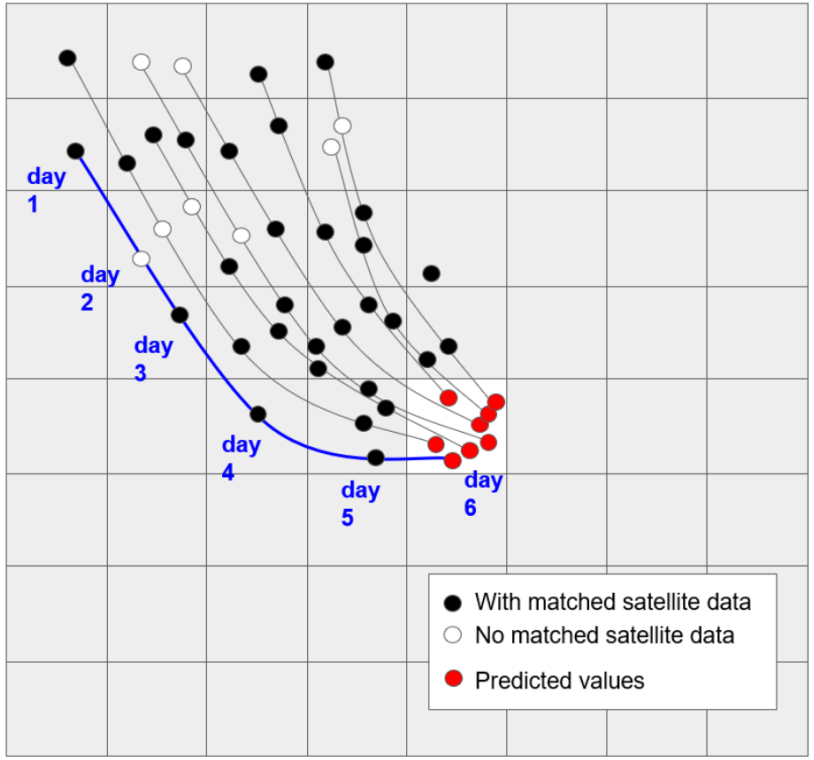
- Ocean colour HAB capabilities
- Merging ocean colour and particle trajectories
- Animations of ocean colour predictions
- Predicting short term HAB risk

PRIMROSE
Predicting the Impact of Regional Scale events on the Aquaculture Sector
Interreg Atlantic Area
European Regional Development Fund
Safe and Sustainable Shellfish
UK AQUACULTURE INITIATIVE
BBSRC bioscience for the future

Ocean colour prediction scheme

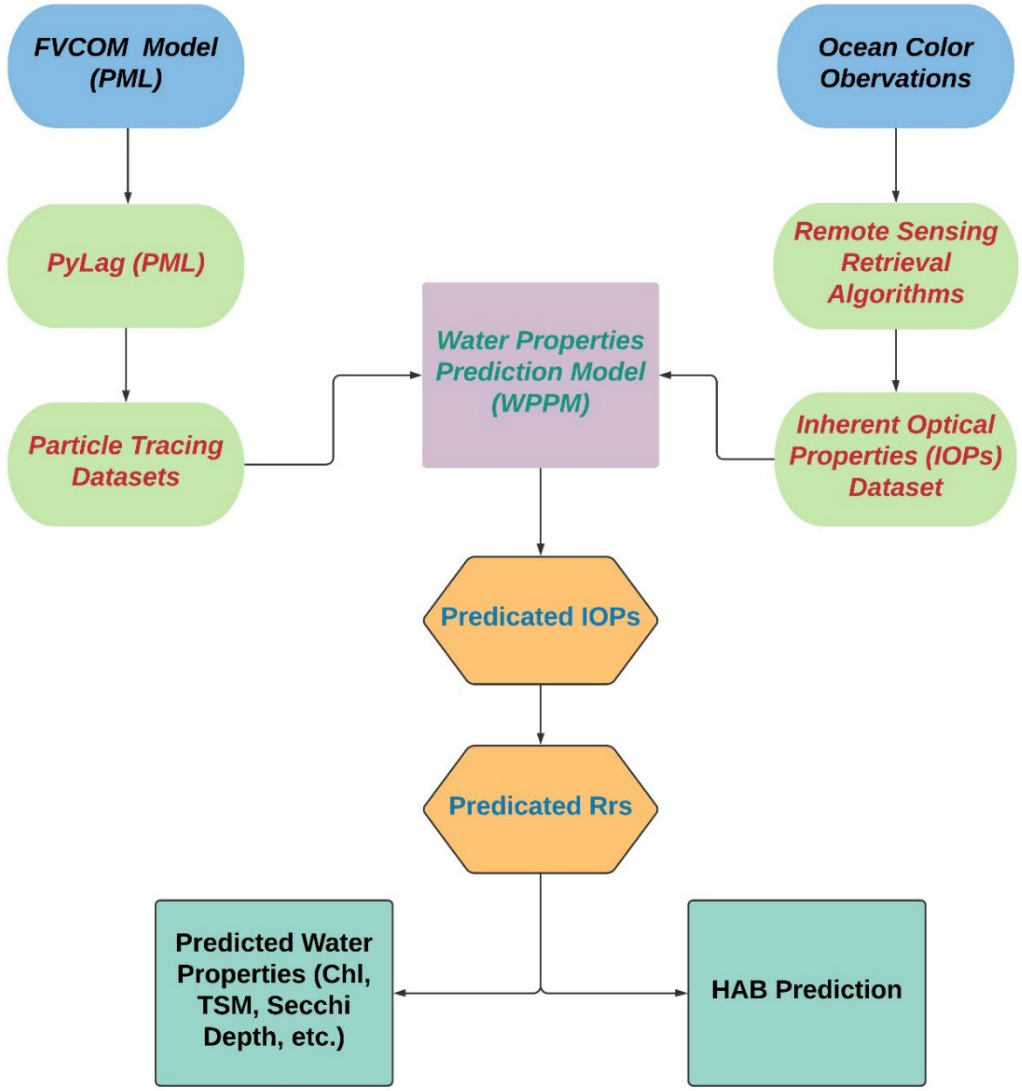
A new technology for short term prediction of HAB events

Particle trajectories for HAB



$$\bar{v} = \sum_{j=1}^{m} \sum_{i=1}^{n} w_{ij} v_{ij}$$

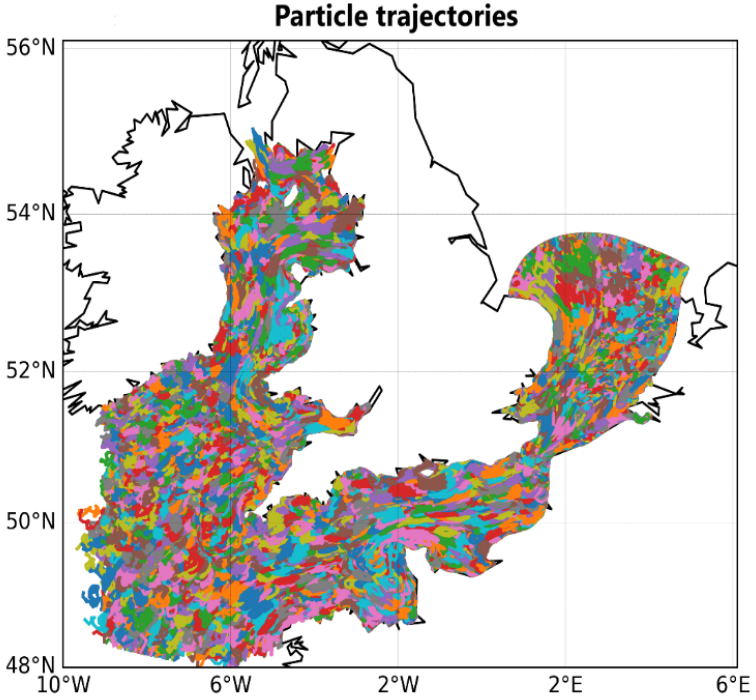
Algorithm Flowchart

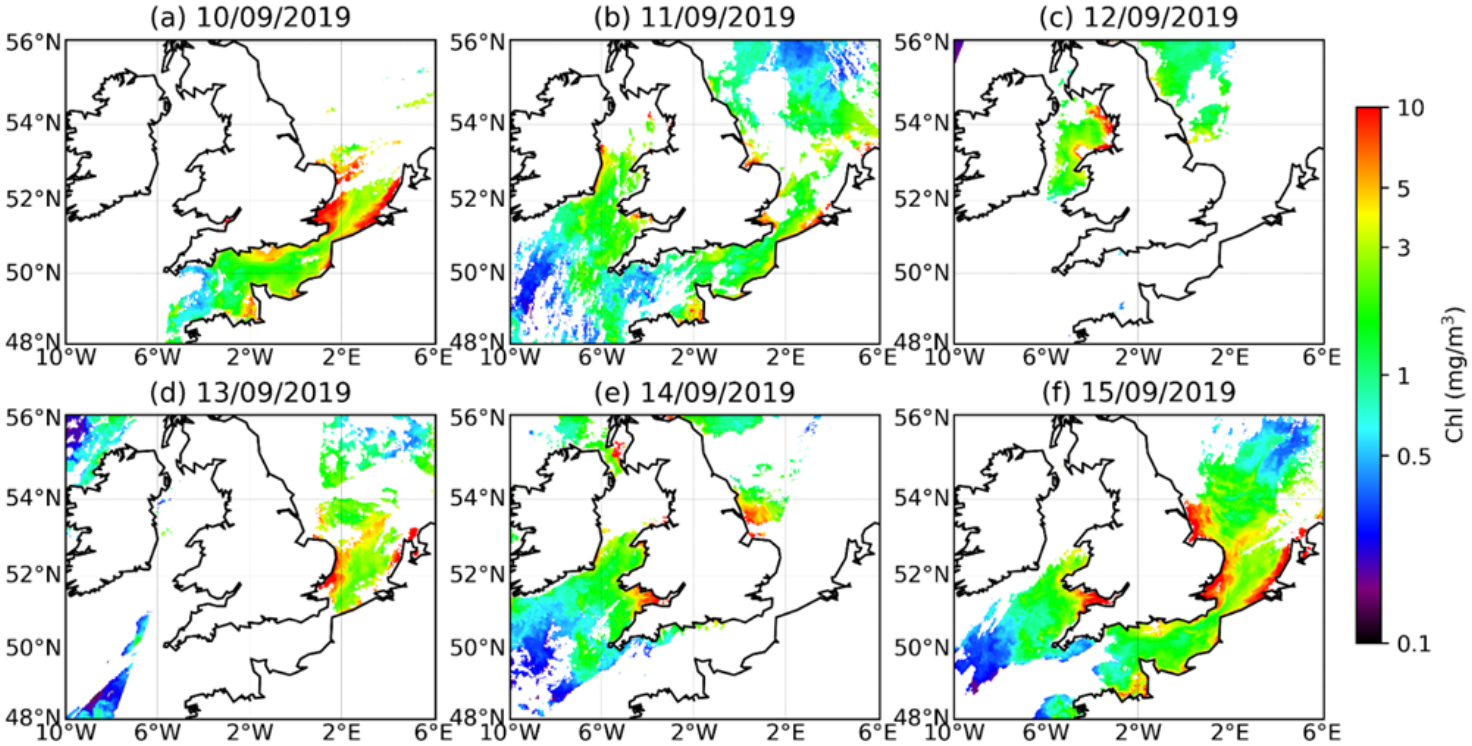


An Example: The Celtic Sea and English Channel

Particle trajectories and ocean colour observations

1. Particle trajectories during 10/09/2019 to 17/09/2019, which were used for an application of the prediction scheme.
2. Maps of Chlorophyll-a concentration during the days with ocean color observations used for prediction of HABs (or other bio-optical parameters).





HAB prediction: ocean colour and particle trajectories

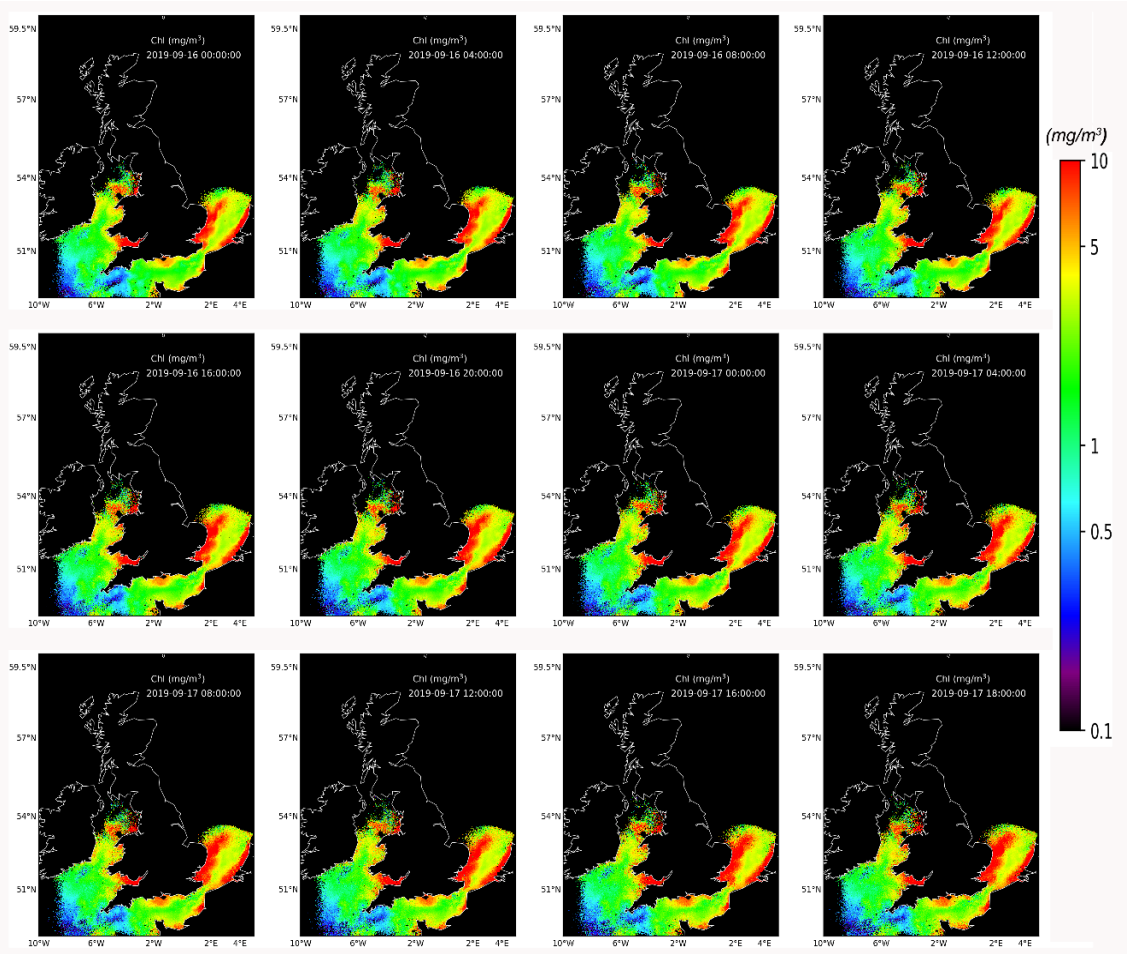
- Ocean colour HAB capabilities
- Merging ocean colour and particle trajectories
- Animations of ocean colour predictions
- Predicting short term HAB risk

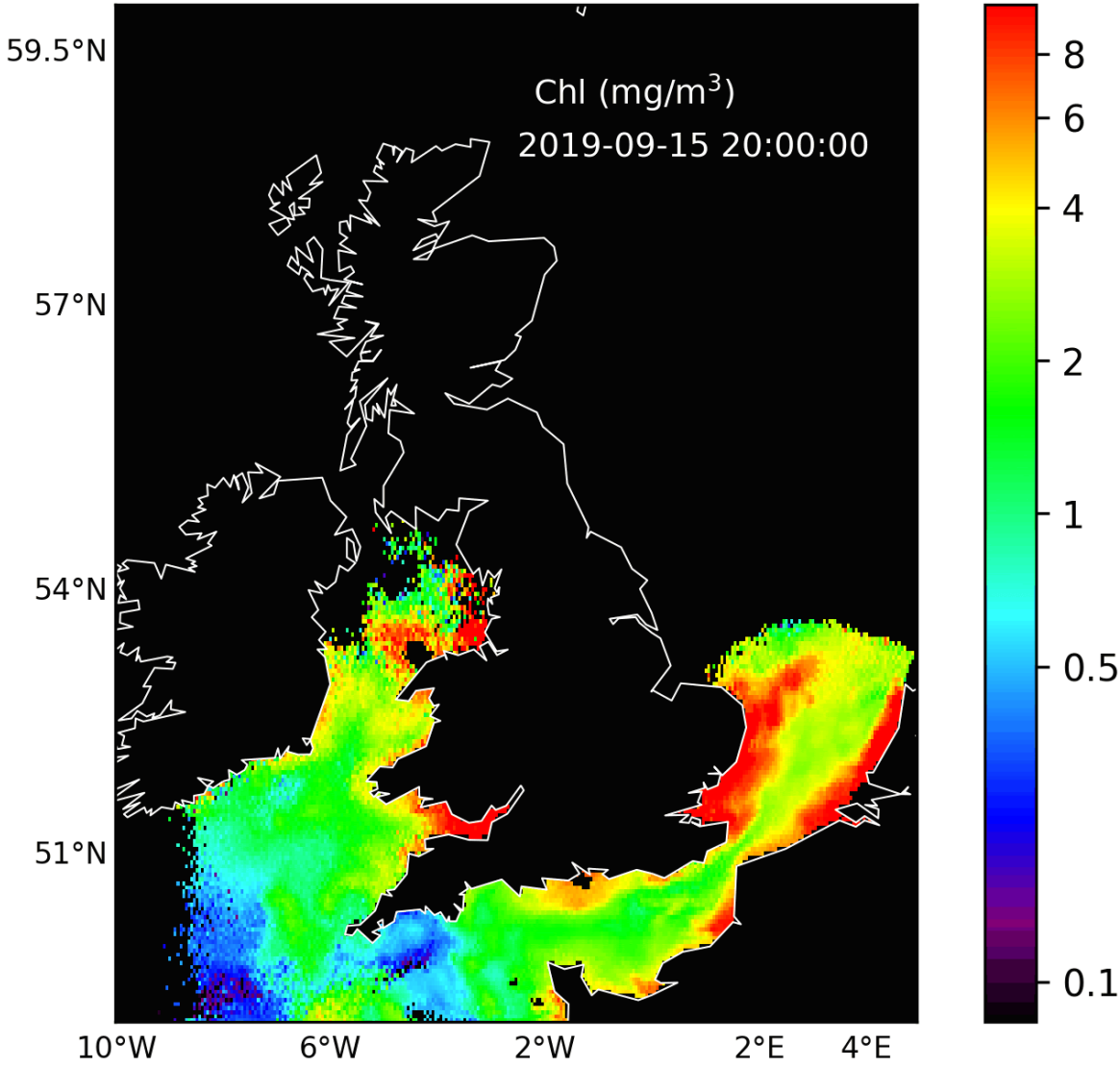
PRIMROSE
Predicting the Impact of Regional Scale events on the Aquaculture Sector
Interreg Atlantic Area
European Regional Development Fund
Safe and Sustainable Shellfish
UK AQUACULTURE INITIATIVE
BBSRC bioscience for the future

Chlorophyll-a predictions

The Celtic Sea and English Channel

1. Frames of predicated Chl distribution at 4-hour intervals.
2. The animation of the sequence of predicted Chl maps.

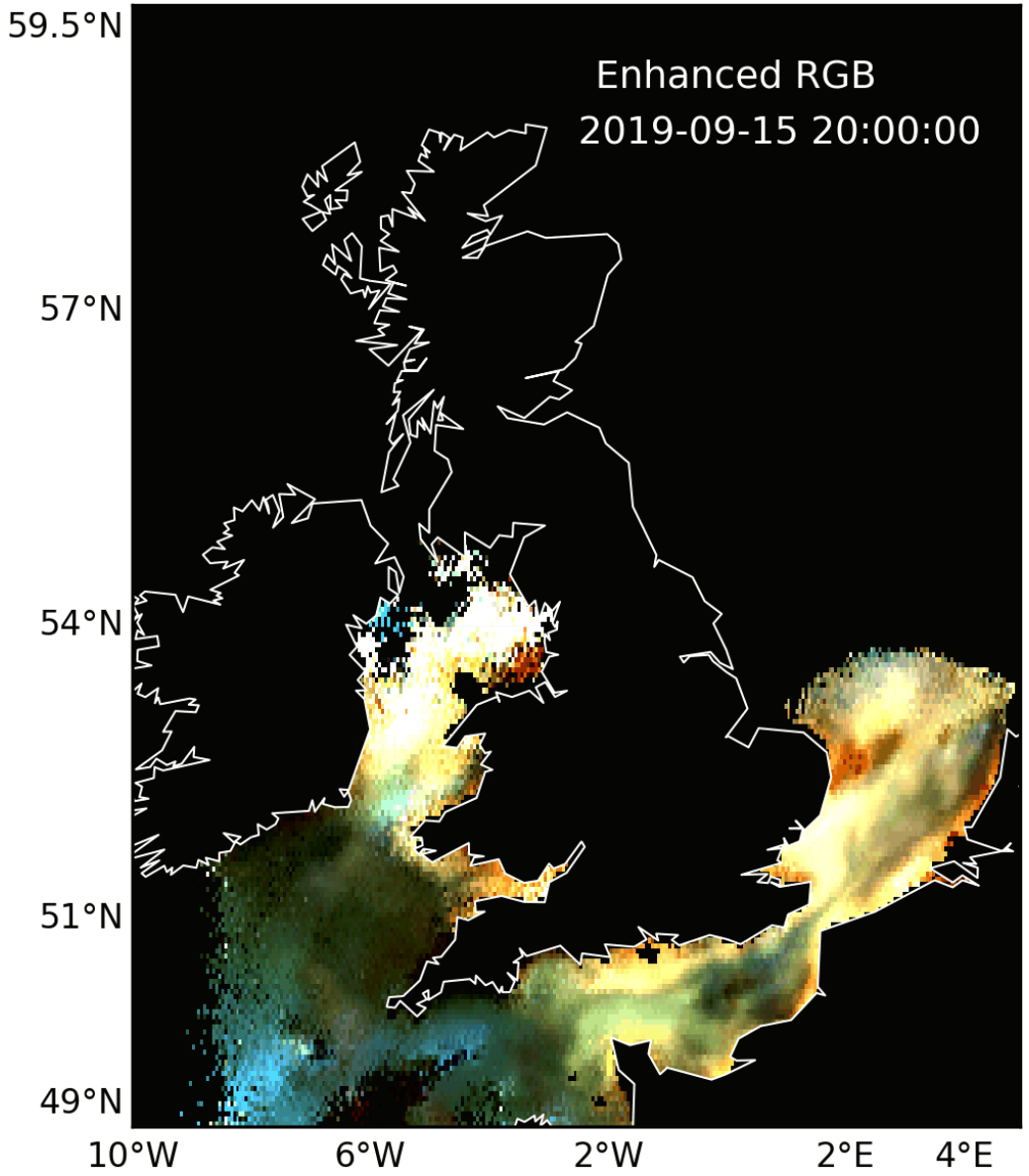




Predicted enhanced true-color results

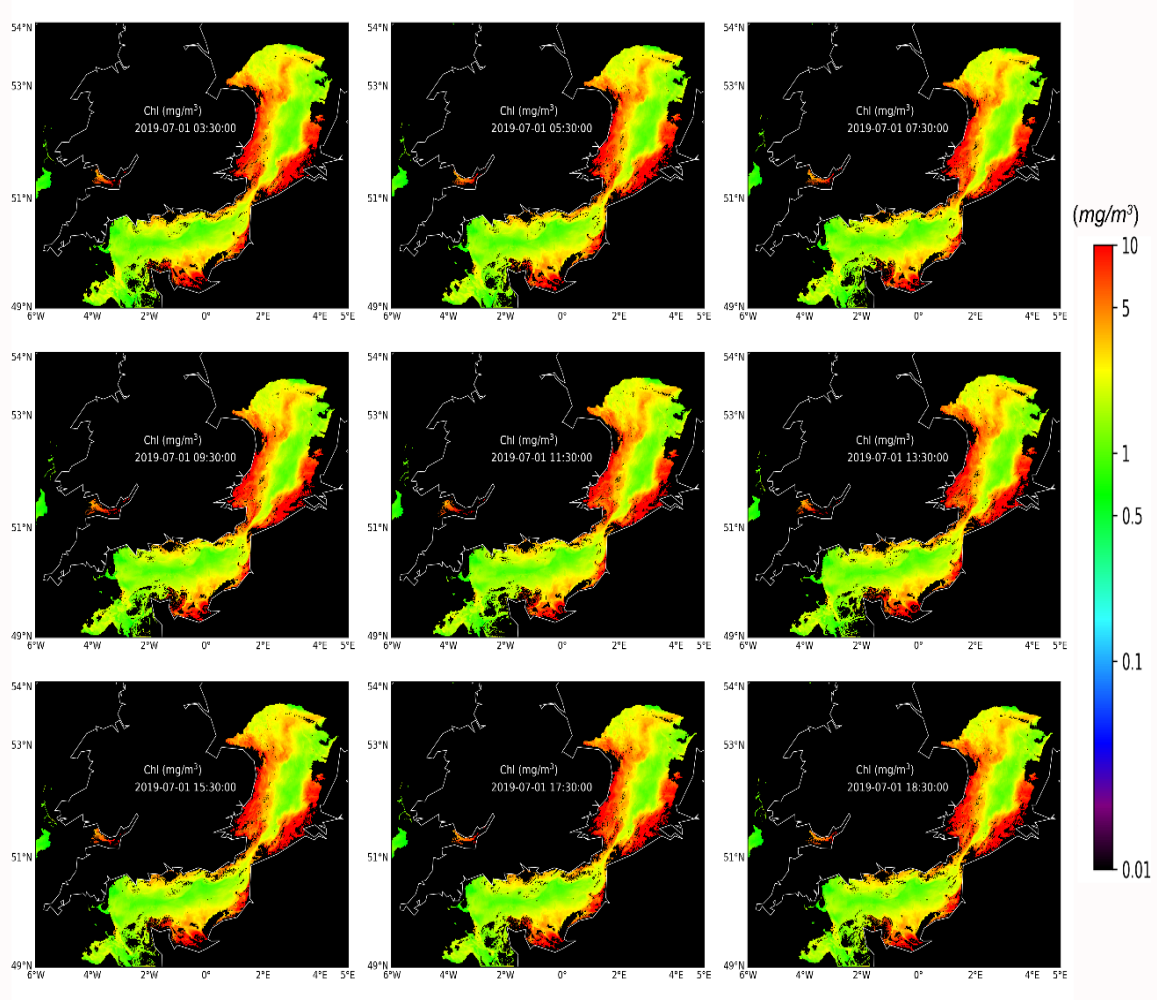
The Celtic Sea and English Channel

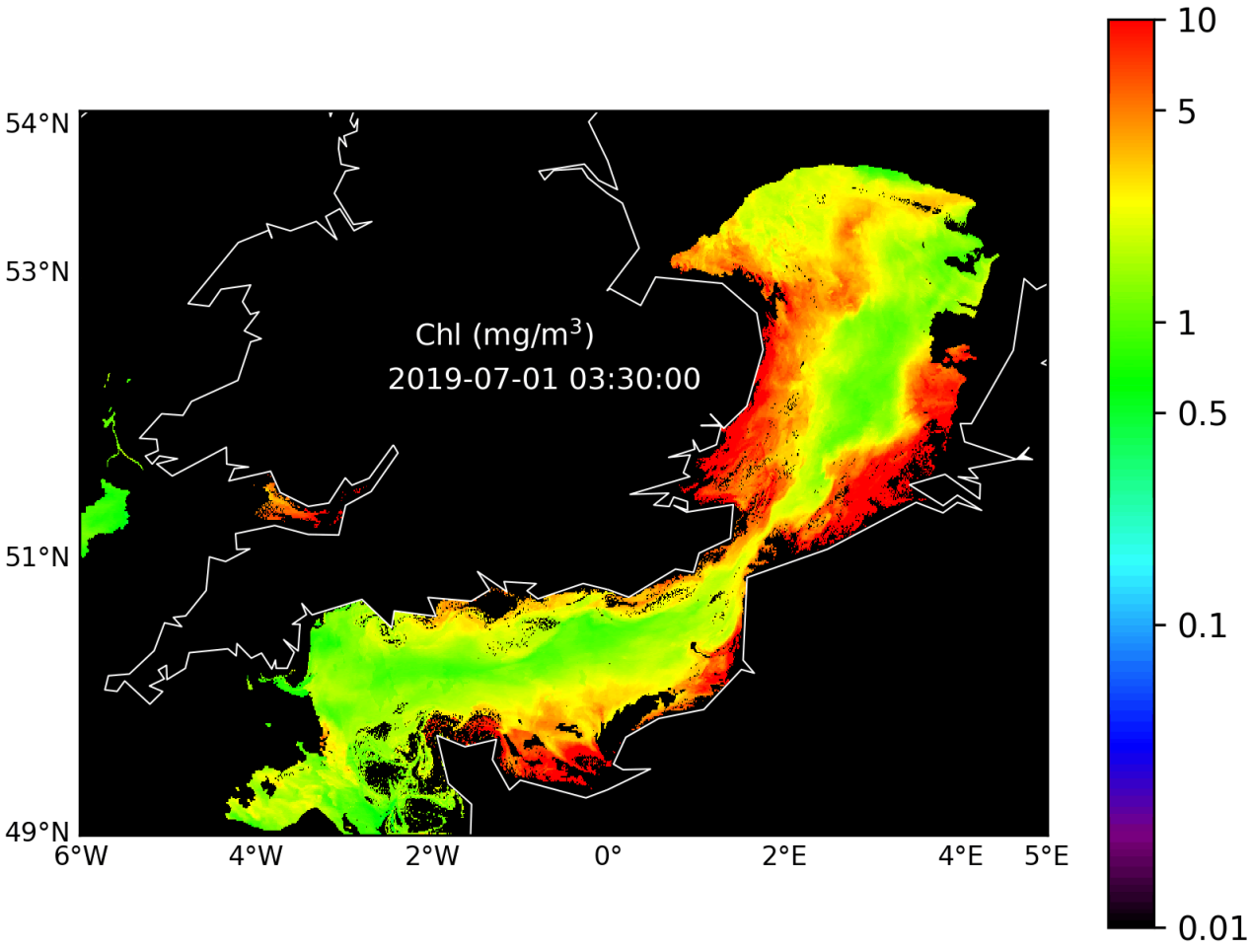
1. Frames of enhanced RGB images indicating variabilities of water types.
2. Animation of the predicted enhanced true-color results.



High spatial resolution in English Channel

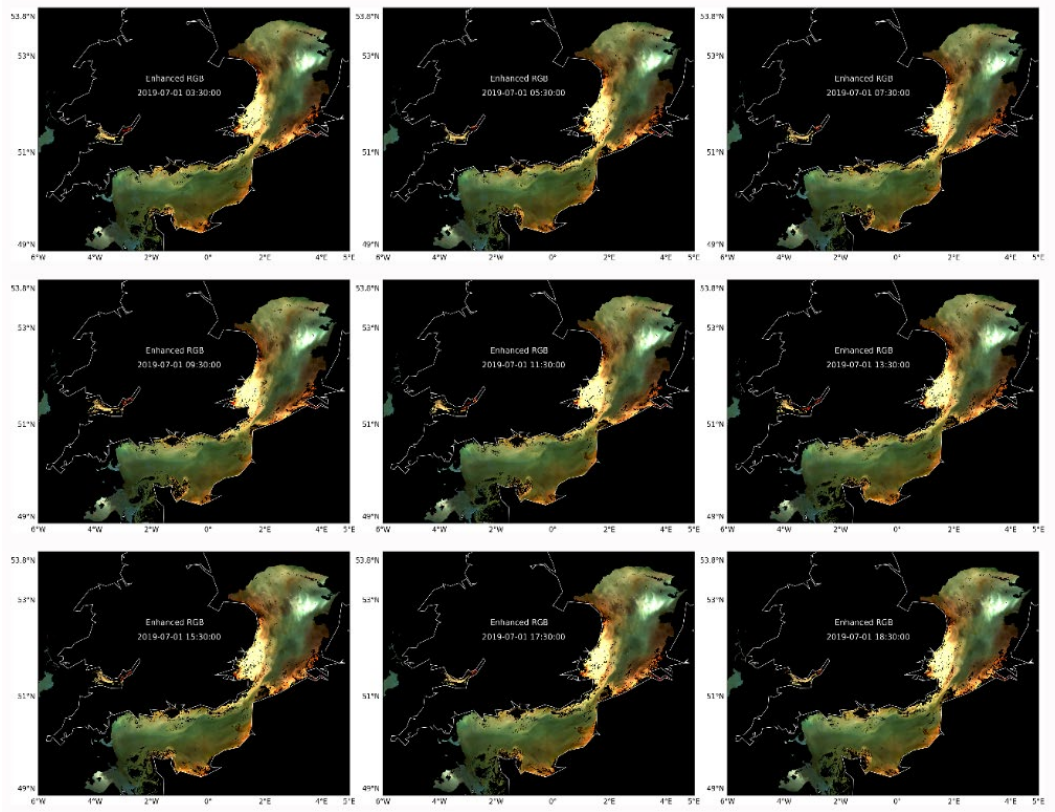
1. Many more particles were seeded (~10 million particles).
2. Small scale structures are interpreted here (e.g. some fine structures of algae patches were revealed).

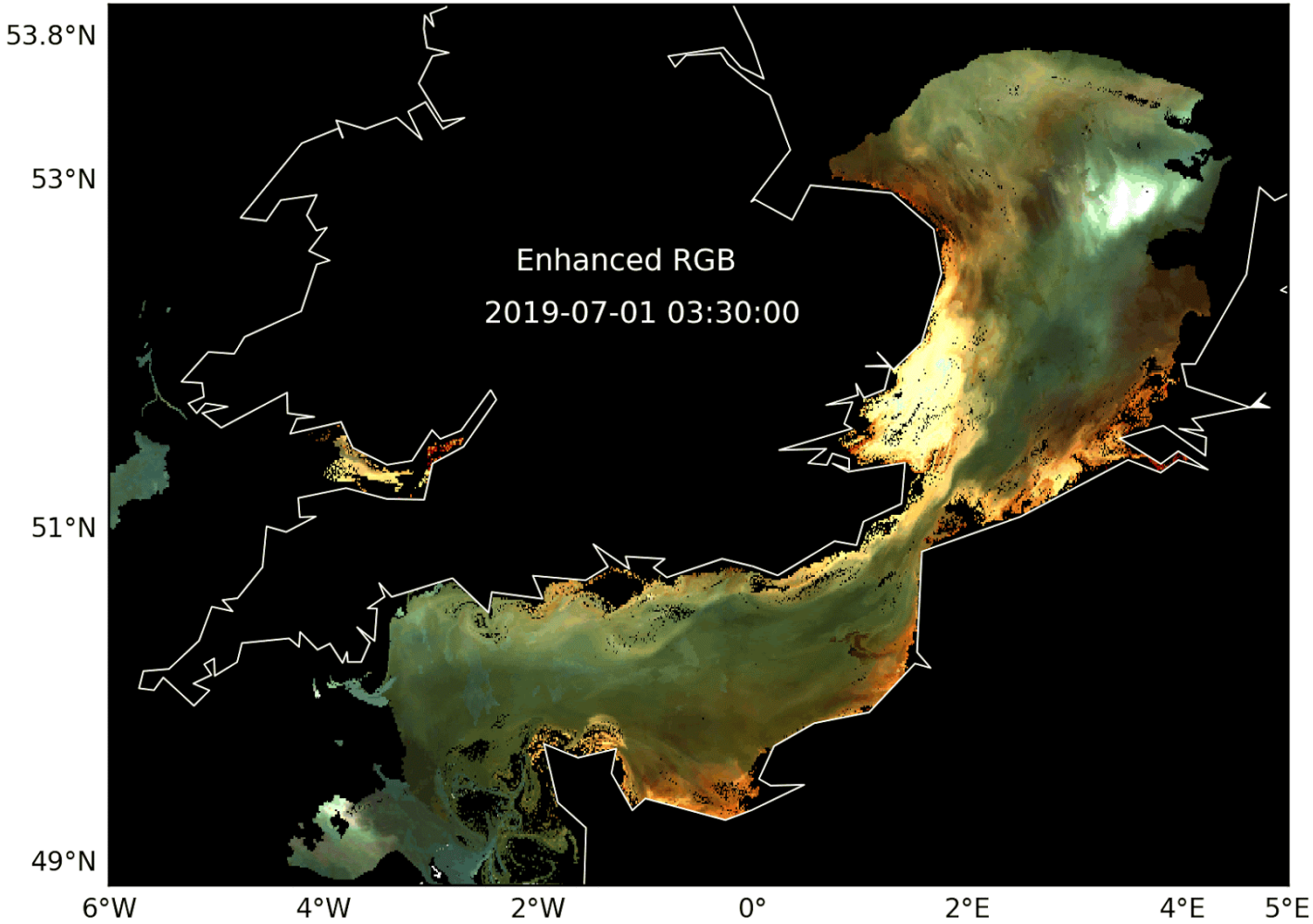




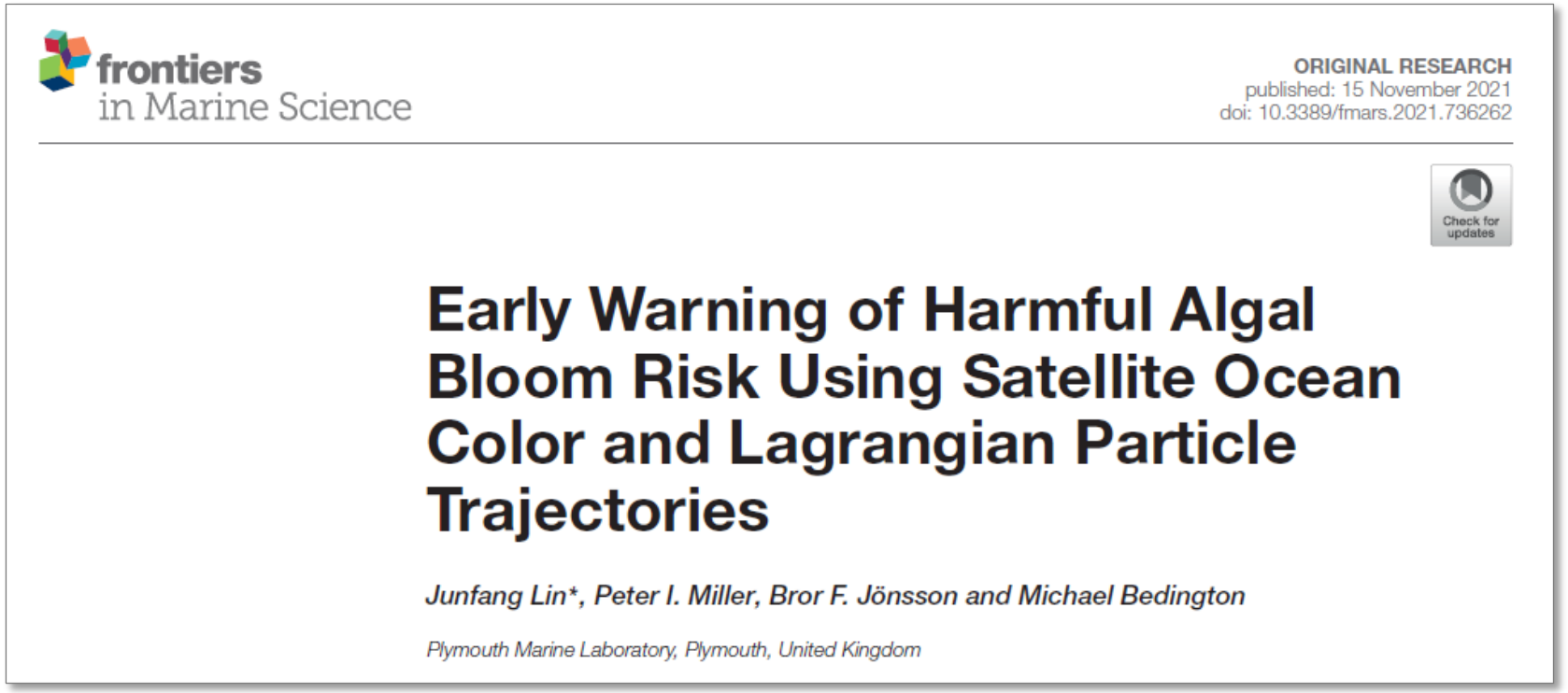
High spatial resolution in English Channel – enhanced true colour

1. Coccolithophorid bloom occurred in the northern English Channel, covering thousands of square kilometers with milky blue.
2. The prediction method here successfully discriminated the locations of the bloom and its advection over time.





Method published in *Frontiers in Marine Science*



frontiers in Marine Science

ORIGINAL RESEARCH
published: 15 November 2021
doi: 10.3389/fmars.2021.736262

Check for updates

Early Warning of Harmful Algal Bloom Risk Using Satellite Ocean Color and Lagrangian Particle Trajectories

Junfang Lin, Peter I. Miller, Bror F. Jönsson and Michael Bedington*

Plymouth Marine Laboratory, Plymouth, United Kingdom

tinyurl.com/habanim

PRIMROSE Predicting the Impact of Regional Scale events on the Aquaculture Sector

Interreg Atlantic Area European Regional Development Fund

Safe and Sustainable Shellfish

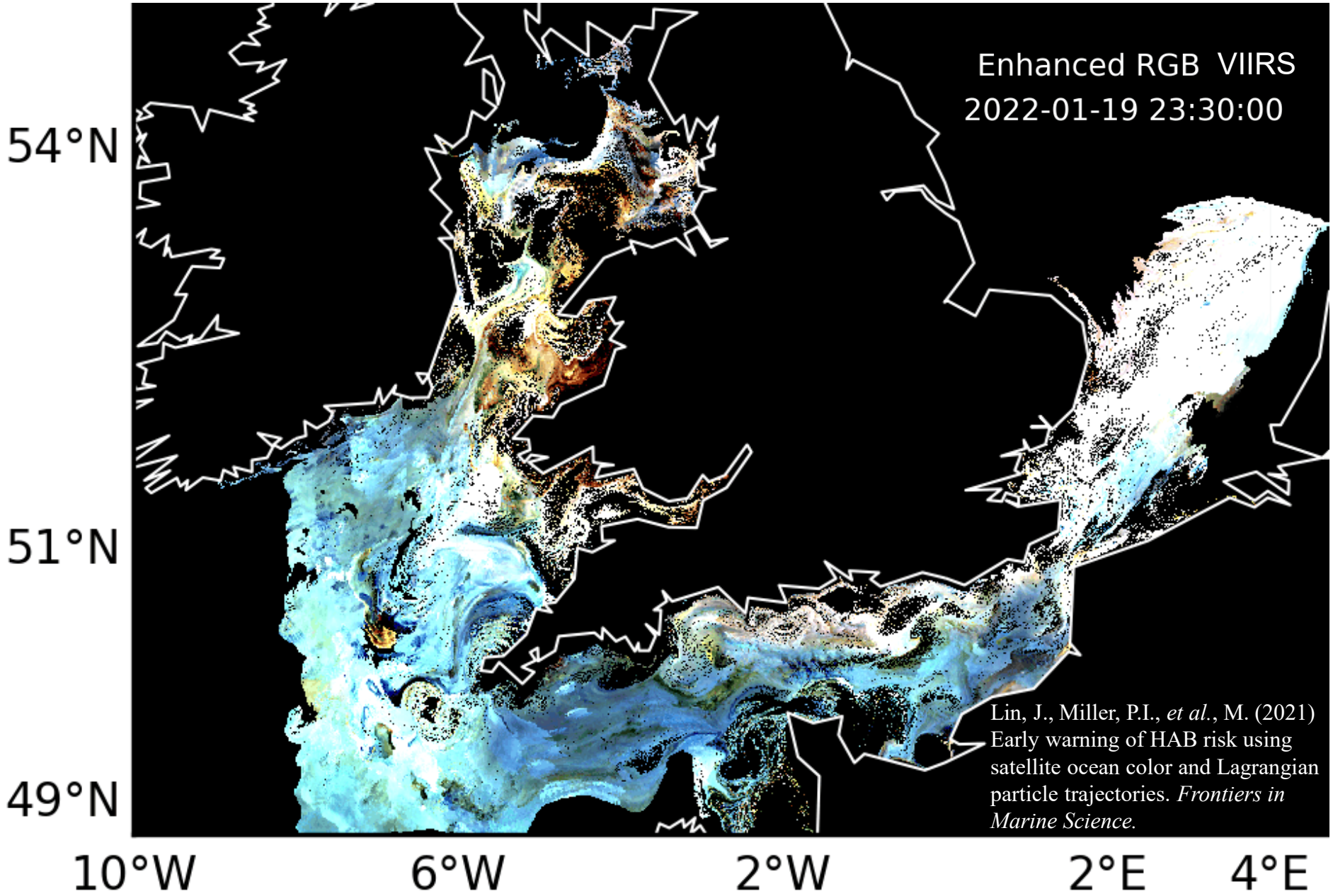
UK AQUACULTURE INITIATIVE

BBSRC bioscience for the future

PML | Plymouth Marine Laboratory

Process now running operationally

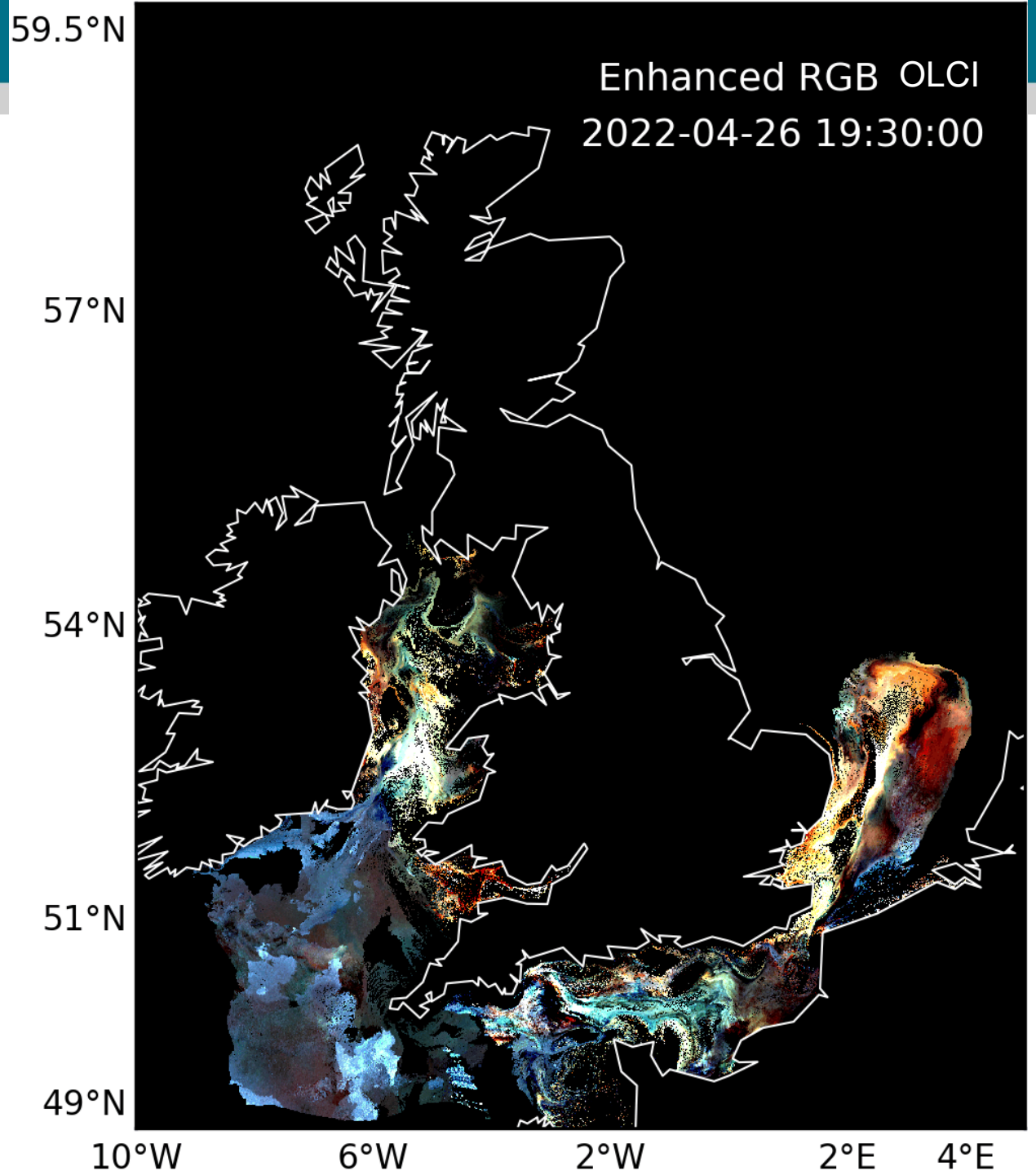
Research excellence supporting a sustainable ocean



Recent enhanced colour prediction using Sentinel-3 300m data

26-28 Apr. 2022

- Bright turquoise patches are coccoliths.
- Dark red is dense bloom.
- Bright orange is suspended sediment.



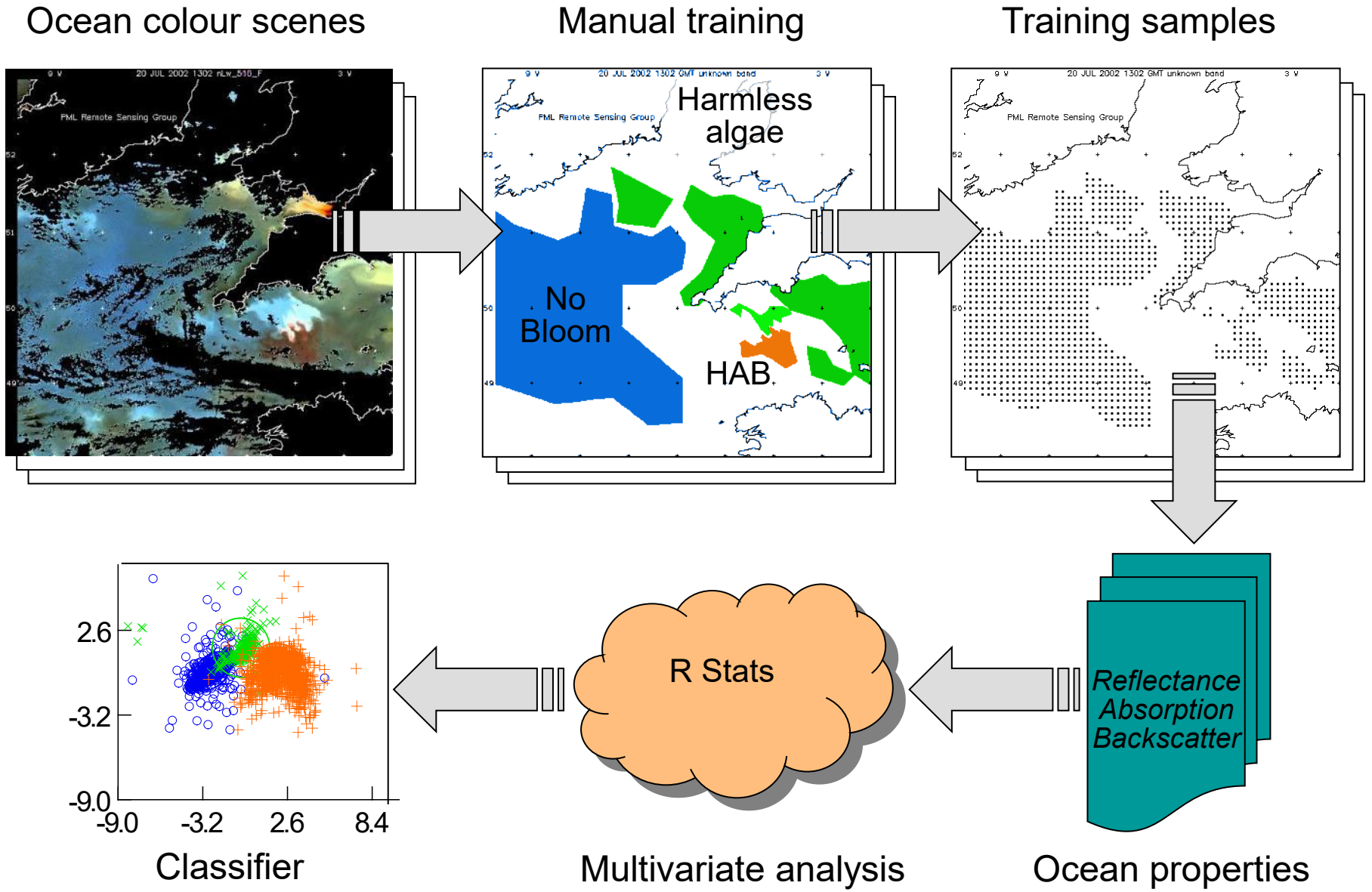
Lin, J., Miller, P.I., *et al.*, M. (2021) Early warning of HAB risk using satellite ocean color and Lagrangian particle trajectories. *Frontiers in Marine Science.*

HAB prediction: ocean colour and particle trajectories

- Ocean colour HAB capabilities
- Merging ocean colour and particle trajectories
- Animations of ocean colour predictions
- Predicting short term HAB risk

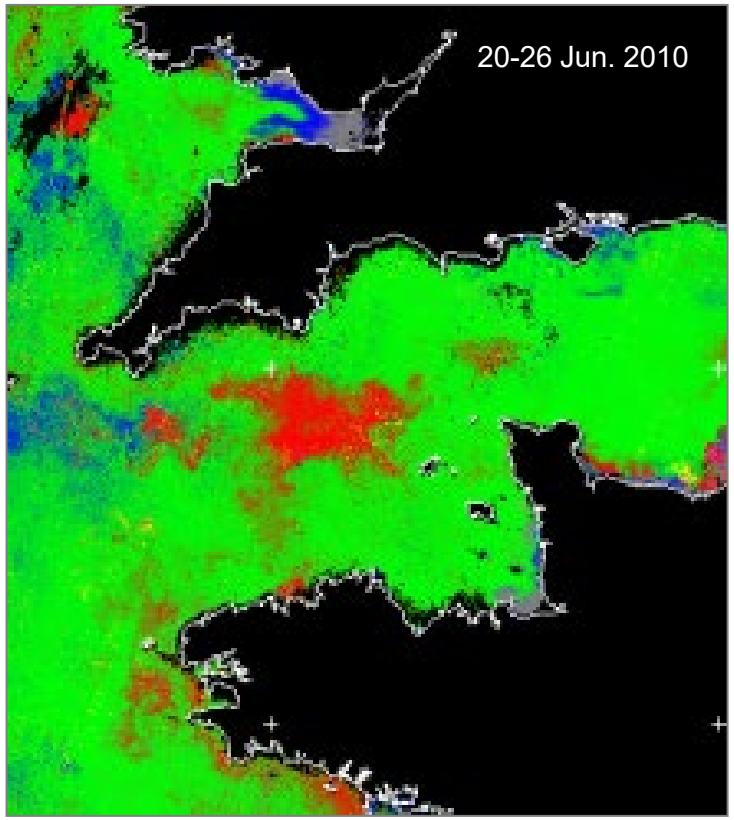
PRIMROSE
Predicting the Impact of Regional Scale events on the Aquaculture Sector
Interreg Atlantic Area
European Regional Development Fund
Safe and Sustainable Shellfish
UK AQUACULTURE INITIATIVE
BBSRC bioscience for the future

Ocean colour HAB discrimination

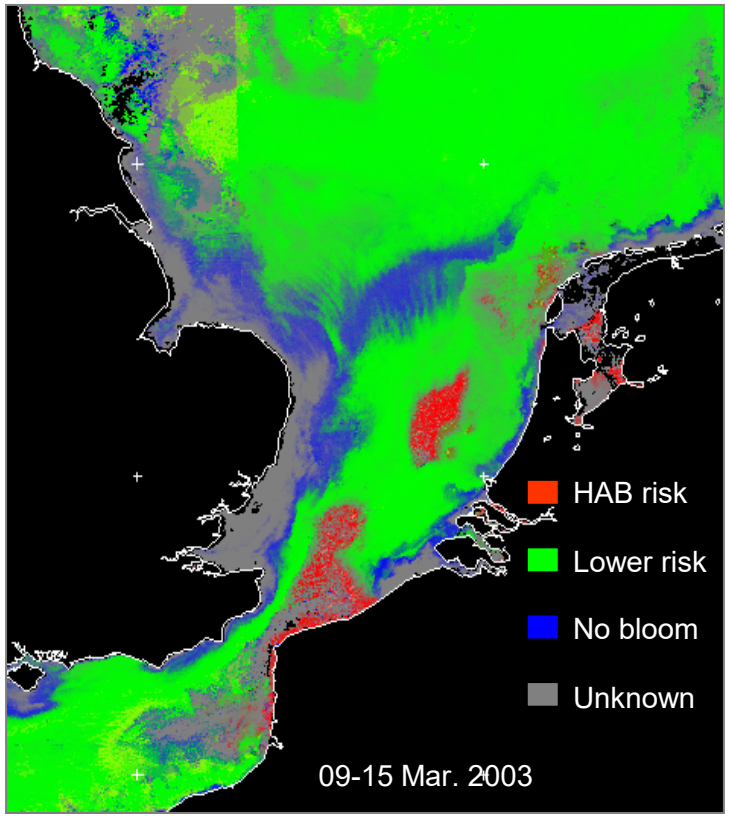


Kurekin, A.A., Miller, P.I. & Woerd, H.J.V.D. (2014) Satellite discrimination of *Karenia mikimotoi* and *Phaeocystis* harmful algal blooms in European coastal waters: merged classification of ocean colour data. *Harmful Algae*, 31, 163-176.

Discrimination of harmful algal blooms



Weekly HAB risk maps of *Karenia mikimotoi* algal bloom in the Western English Channel in summer 2010



Phaeocystis globosa bloom in the Southern North Sea in spring 2003

- HAB risk
- harmless
- no bloom
- not classified

Kurekin, A.A., Miller, P.I. & Woerd, H.J.V.D. (2014) Satellite discrimination of *Karenia mikimotoi* and *Phaeocystis* harmful algal blooms in European coastal waters: merged classification of ocean colour data. *Harmful Algae*.

Particle tracing for prediction of HABs

Slides removed as paper in preparation

Conclusions

- We developed a novel prediction scheme for monitoring HABs by merging satellite observations and Lagrangian particle tracking.
- Two case studies in regions along the coast of England demonstrate improved interpretation of satellite data for early warning of HAB risk.
- Animated sequences promote greater understanding and usage of satellite ocean colour data for communicating with aquaculture farmers
- We seek further applications and development of this new technique to support the aquaculture industry with improved early warning of potential HABs.

Peter Miller pim@pml.ac.uk