Observational Decadal Trends in Phytoplankton abundance and composition In Irish inshore aquaculture areas

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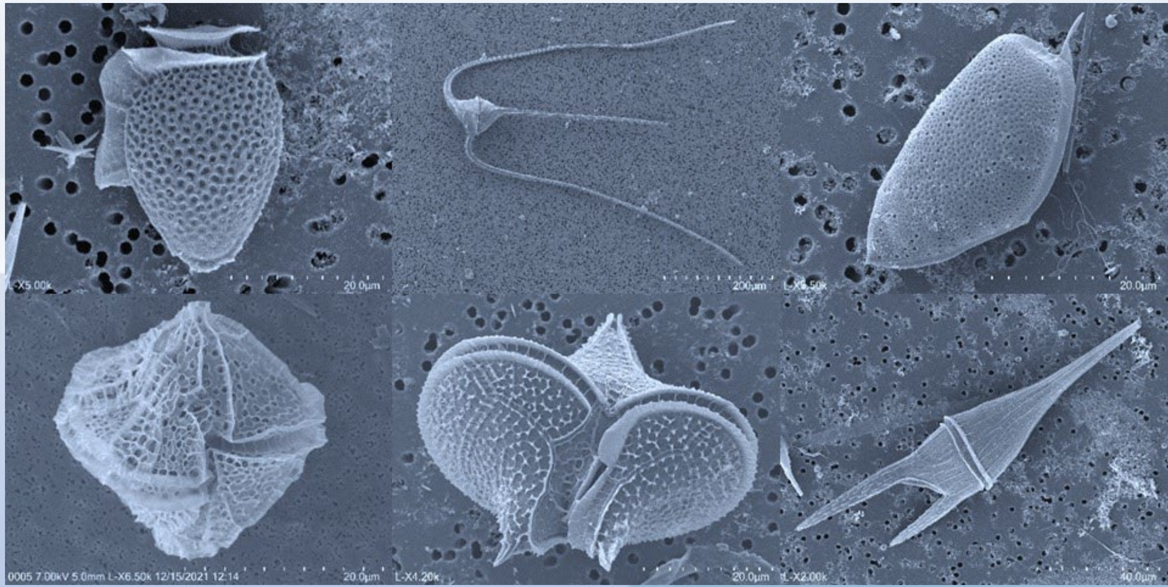
Phytoplankton

Marine phytoplankton are responsible for c. 50% of the primary production on Earth.

A phytoplankton group known as harmful algae with ~200 species know globally. Harmful algae are broadly split into two sub-groups; toxin and non-toxin producing species that can cause harmful effects to marine ecosystems and/or cause seafood safety issues. Toxins produced include Phycotoxins (which can cause harm and impact human health if contaminated shellfish are consumed) and Icthyotoxins (responsible for fish kills). Non-toxin producing high biomass phytoplankton bloom species can result in negative marine ecosystem effects including anoxia, water discolouration, mucilage, and mechanical damage to fish gills.

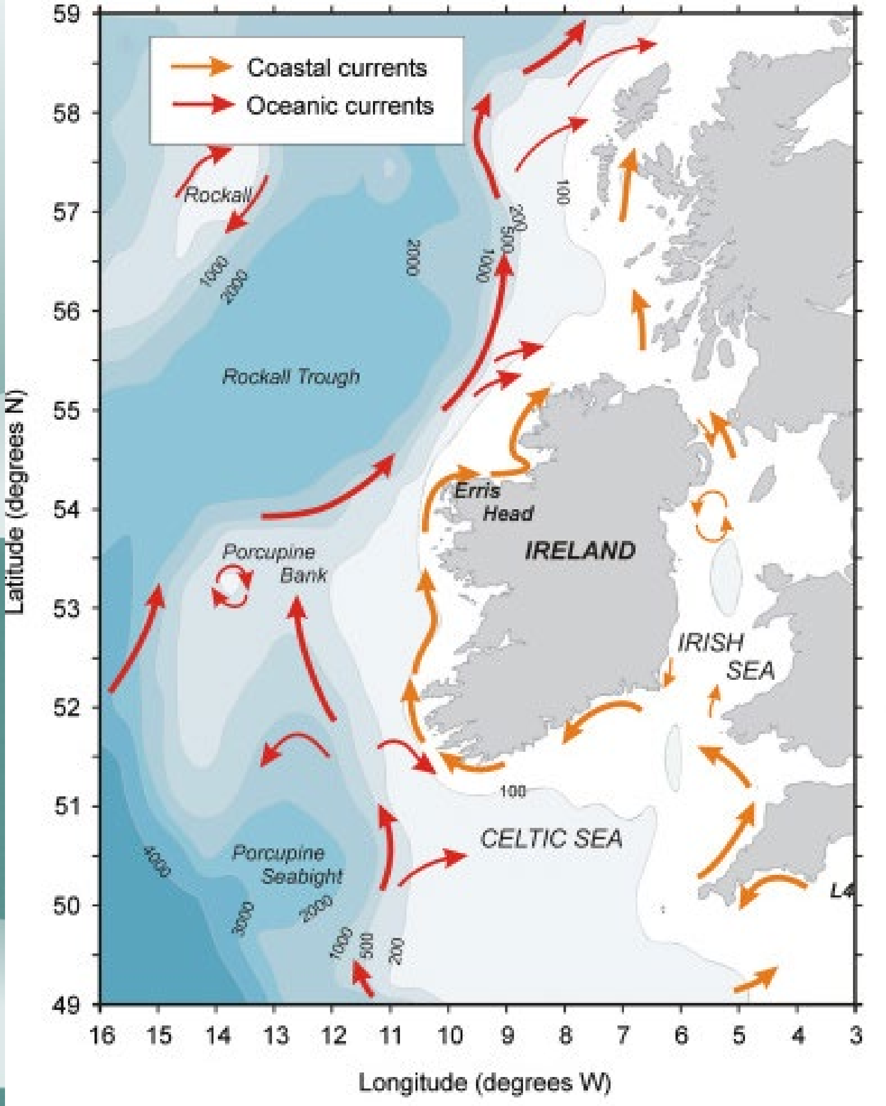


Phytoplankton in Irish Coastal Waters

The phytoplankton community composition in Irish coastal waters is influenced by ocean current circulation patterns and seasonal changes of light availability, nutrients, salinity, temperature and other variables. Inshore marine areas, remain relatively well mixed in winter with intermittent water column stratification due to freshwater runoff from land. In the warmer months, thermal stratification influences phytoplankton growth from March to September.

Offshore, in shelf waters, the transport of phytoplankton is associated with the Irish Coastal Current with bottom density fronts playing an important role for the development and transport of blooms in summer and autumn. The transport of phytoplankton and HABs into the bays of southwest Ireland are primarily driven by wind.

Phytoplankton can be thought of as sensitive indicators of climate change, where changes in community composition can affect and alter marine ecosystems.



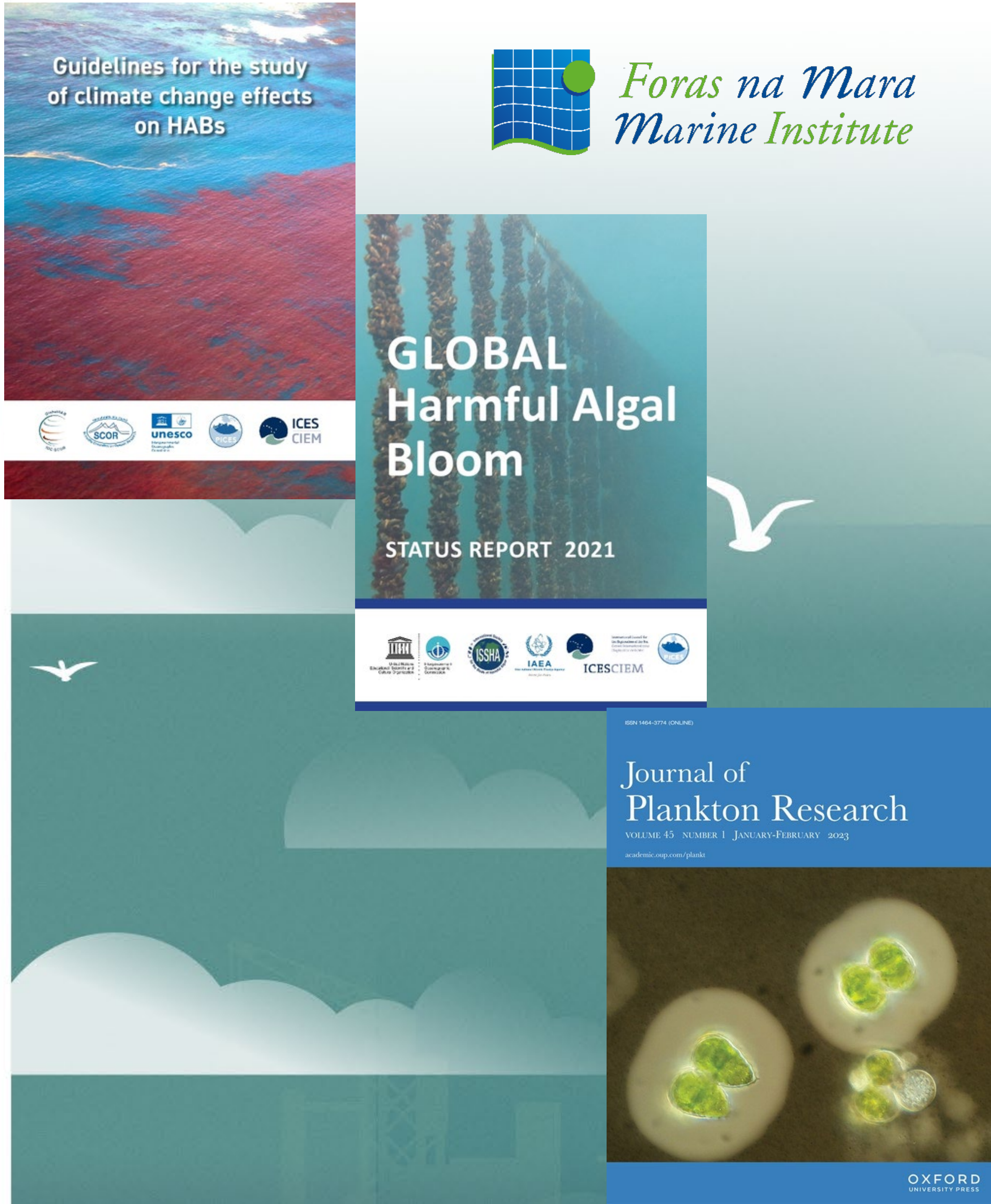
A review of the biophysical interactions relevant to the promotion of HABs in stratified systems: The case study of Ireland (Raine et al. 2014)

Climate Change Impacts on Phytoplankton

Climate change impacts on HAB species are of a global concern with many unknowns and scientific questions on how phytoplankton and HAB species will adapt to future changes in the marine environment (Wells et al., 2021).

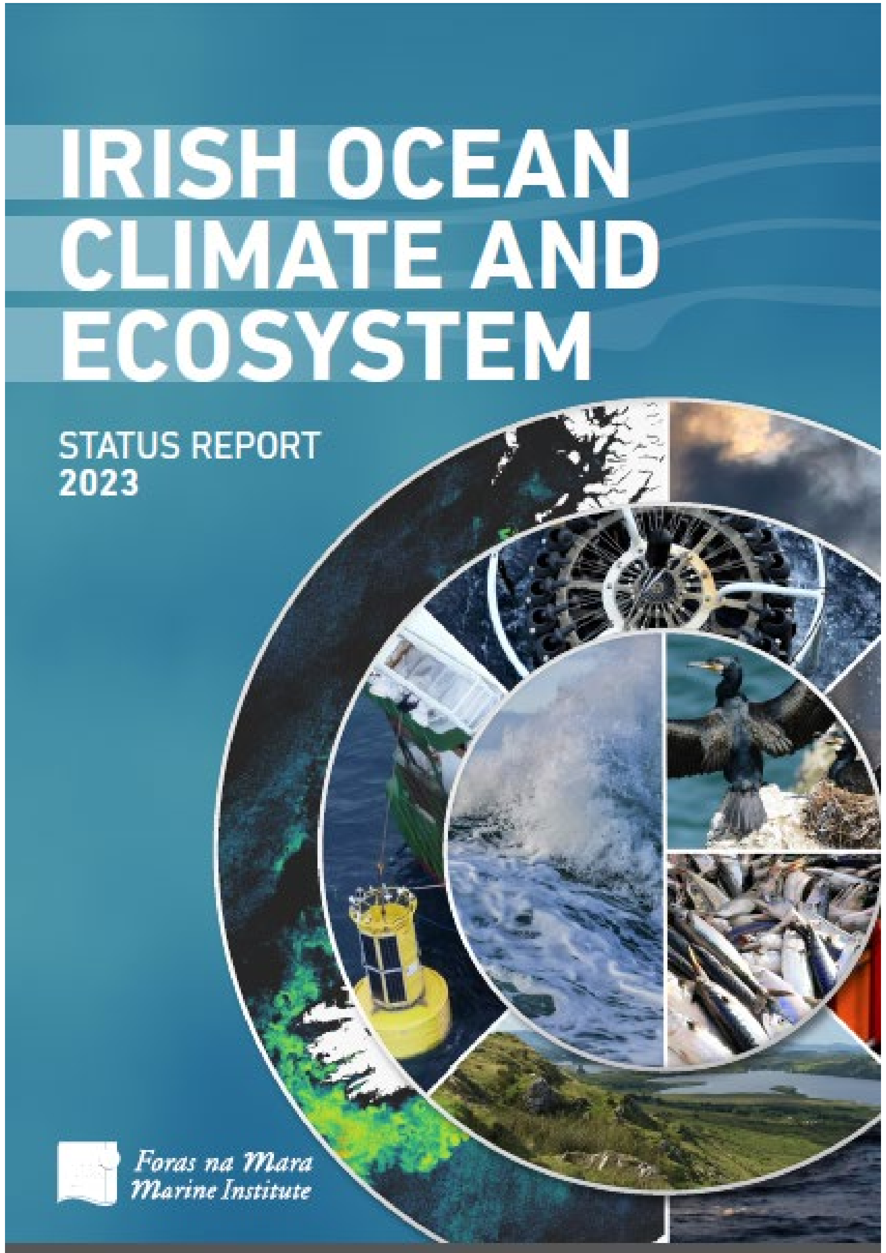
Physical and biogeochemical changes that influence water column stratification, temperature, ocean acidification, and salinity could lead to changes in phytoplankton distributional ranges and an extension of the growth season in some regions (Edwards et al., 2020).

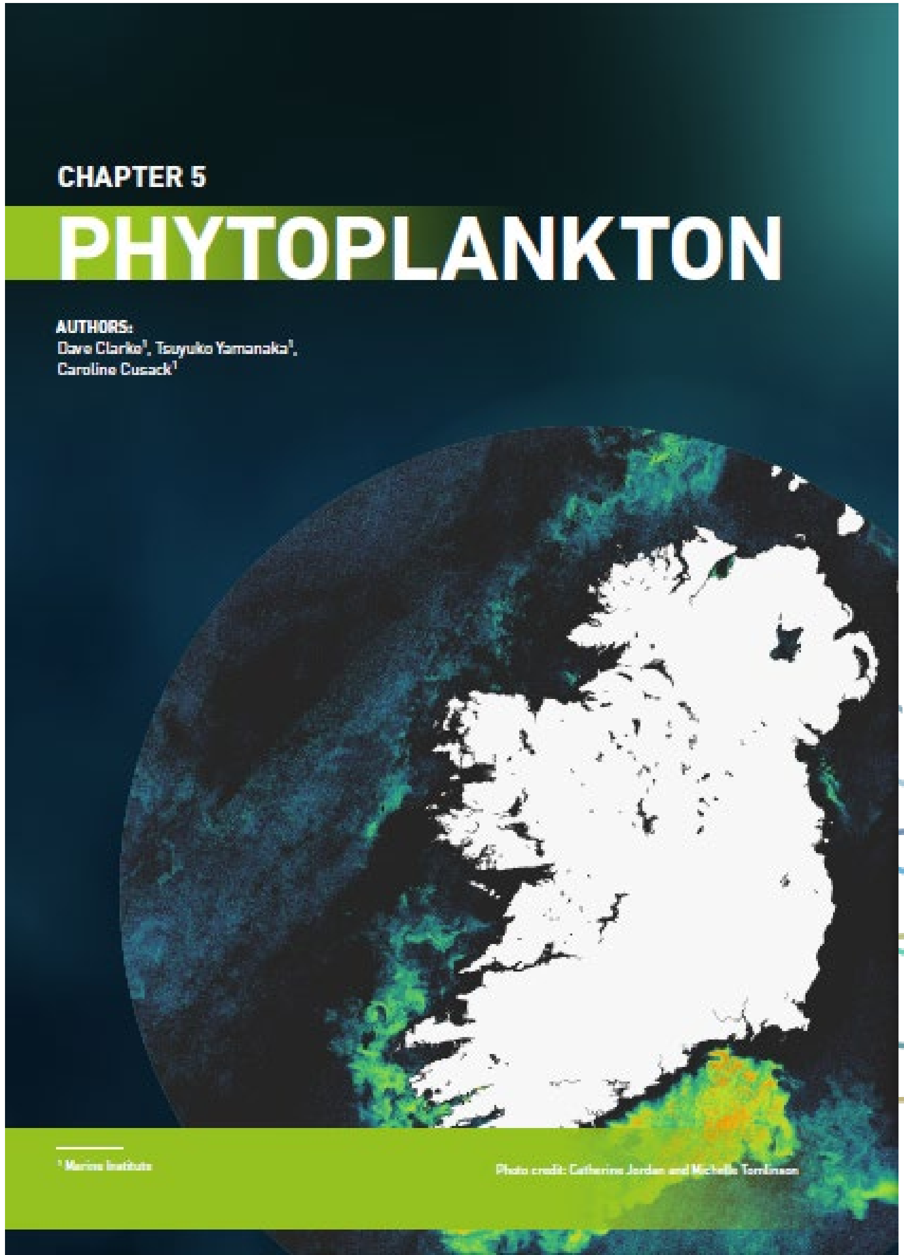
In a world with an increasing human population and a demand for increased global food production from aquaculture, there is uncertainty around climate change impacts on shellfish species settlement and growth, the carrying capacity of bays and physical processes such as flooding, coastal erosion and storms affecting coastal and intertidal habitats.



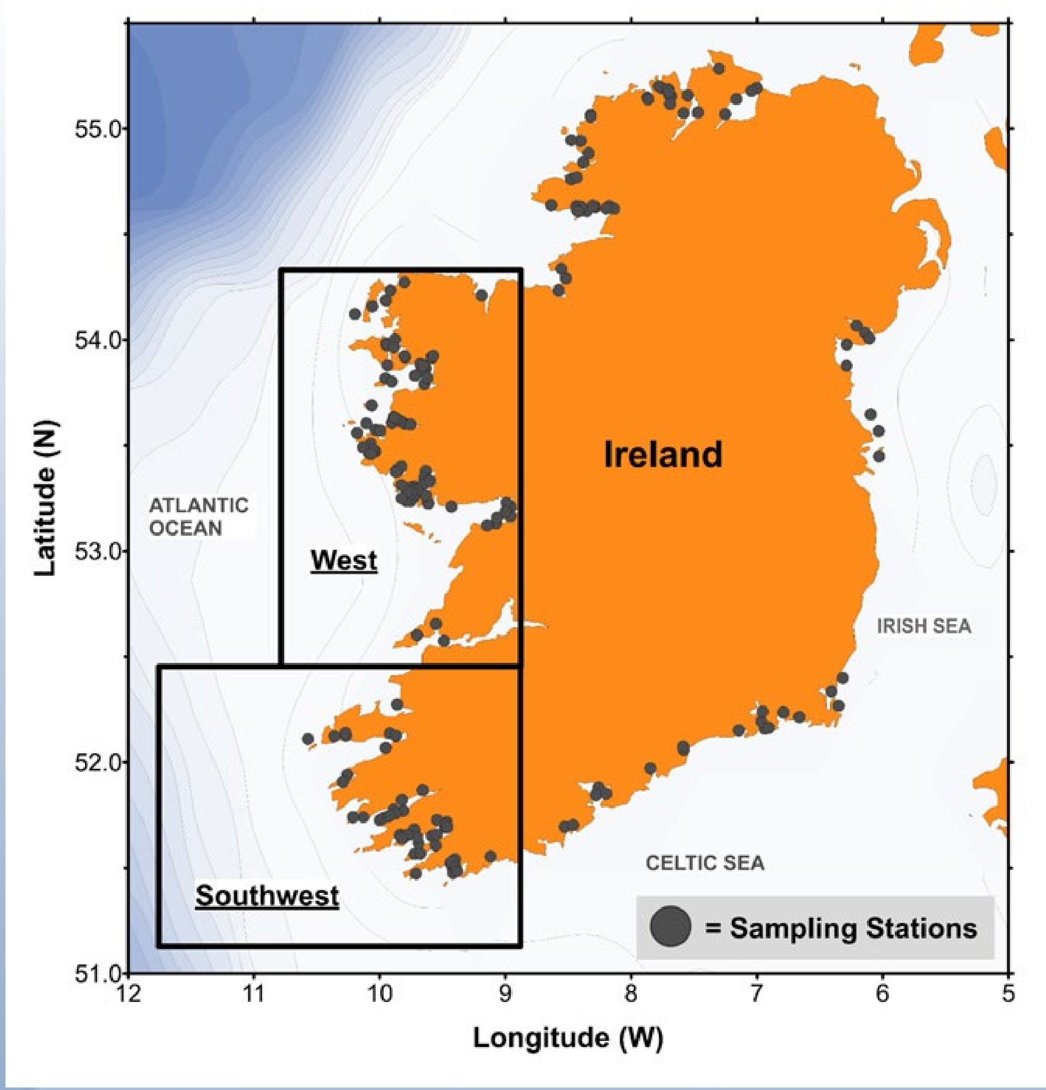
[Irish Ocean Climate and Ecosystem Status Report (marine.ie)]

[Chapter 05: Phytoplankton (marine.ie)]





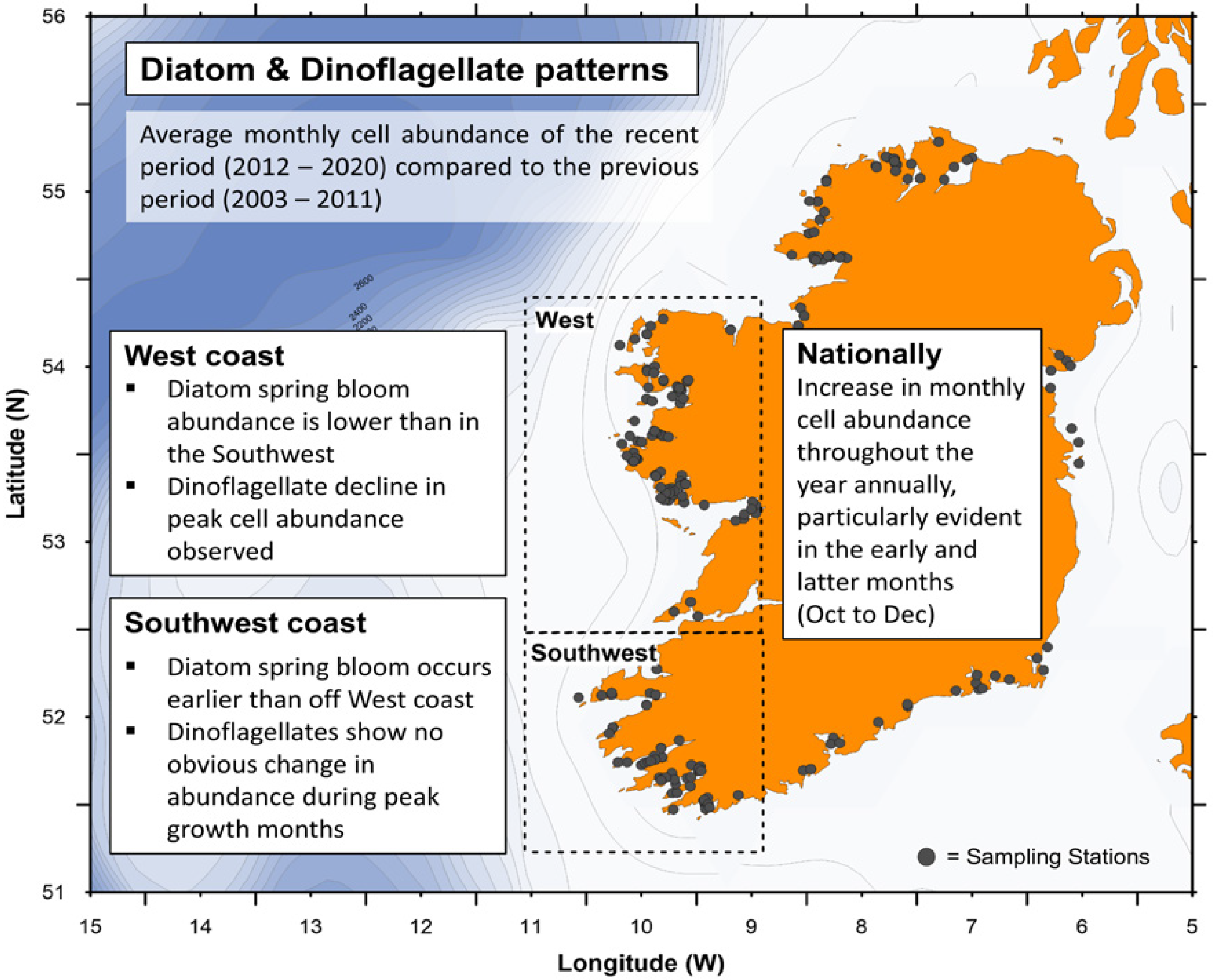
Decadal Review of Changes in Phytoplankton abundance and distribution

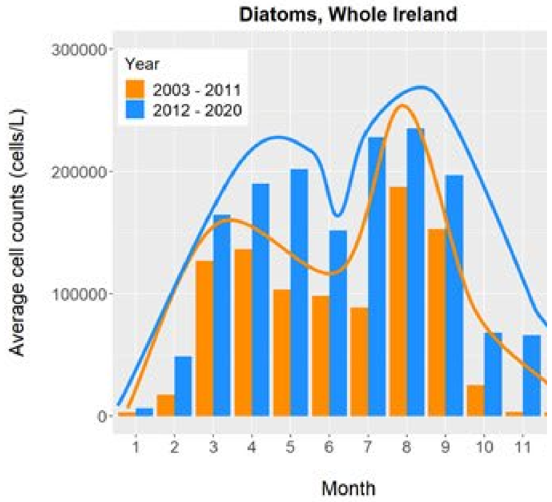


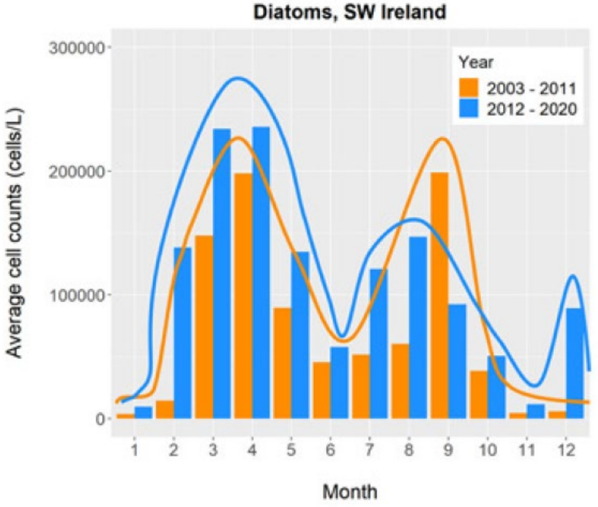
The Irish National Monitoring Programme (NMP) for Phytoplankton commenced in the mid 1980s and was setup to identify and enumerate phytoplankton species (with a particular emphasis on harmful algae) in coastal areas where licensed finfish and shellfish aquaculture operations take place. In the early 2000s, the programme was improved and expanded, and from 2014 onwards, circa 70 samples were collected and analysed weekly in actively harvesting production areas.

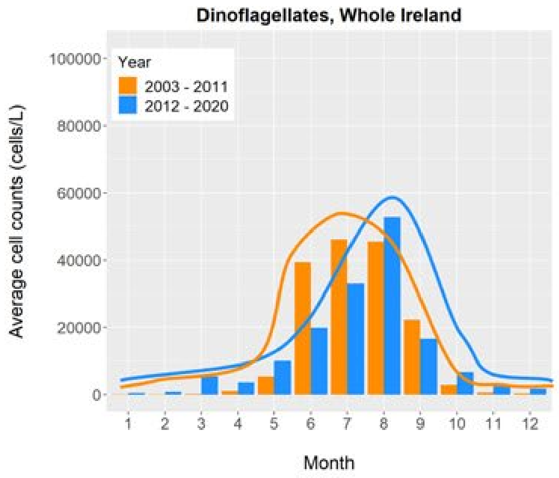
Phytoplankton data (average monthly cell abundance) used in this chapter covers the time period from 2003 to 2020 for three main phytoplankton groups: diatoms, dinoflagellates and ‘all community’ species. For the HAB species detailed in this review, a slightly expanded dataset from 2001 to 2020 was used. For both data sets, results were compiled into three areas, referred to as the 'whole Ireland' where all NMP coastal site data was included, and for two specific regions where intensified aquaculture production activities occur, i.e., the “west” and the “southwest”

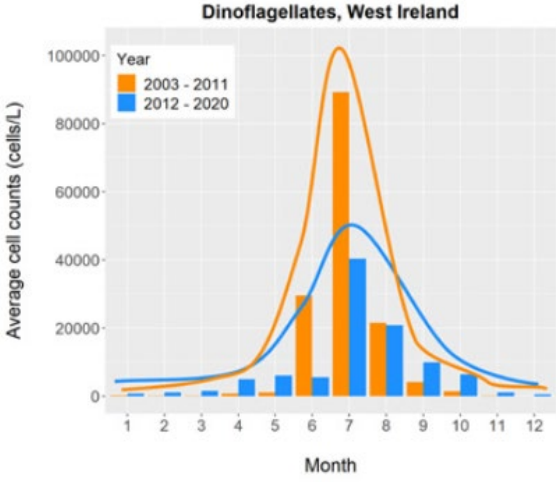
Dinoflagellate and Diatom abundance and distribution











Alexandrium spp. abundance and distribution

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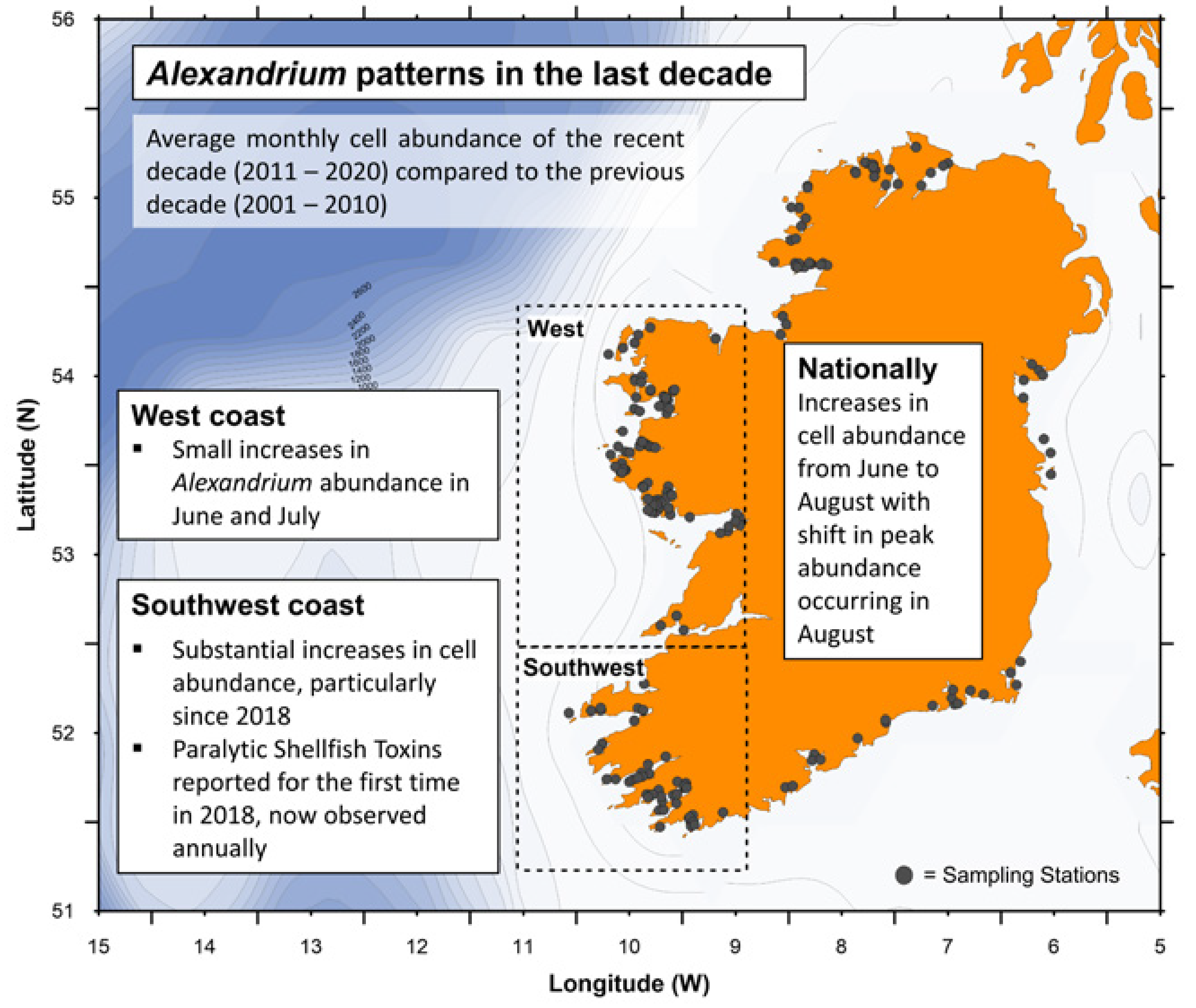

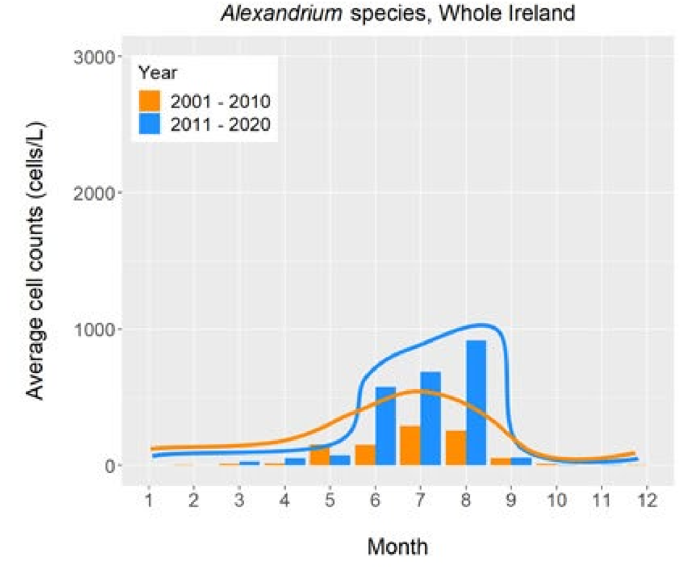

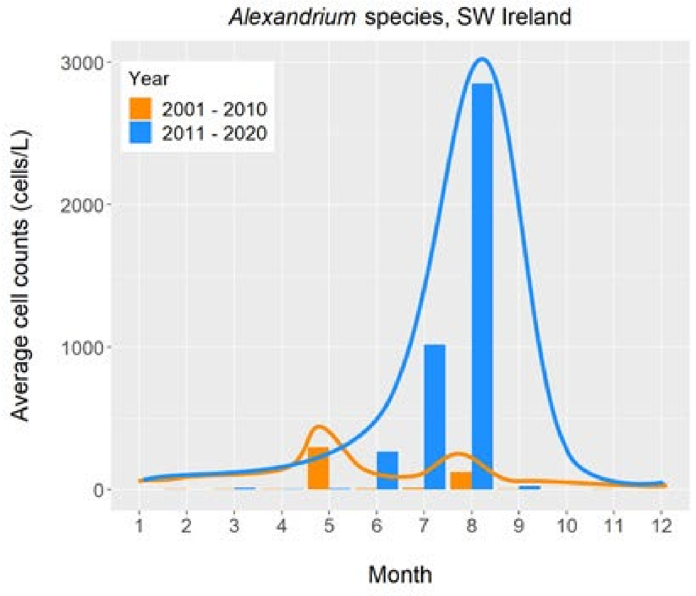

Alexandrium spp. abundance and distribution

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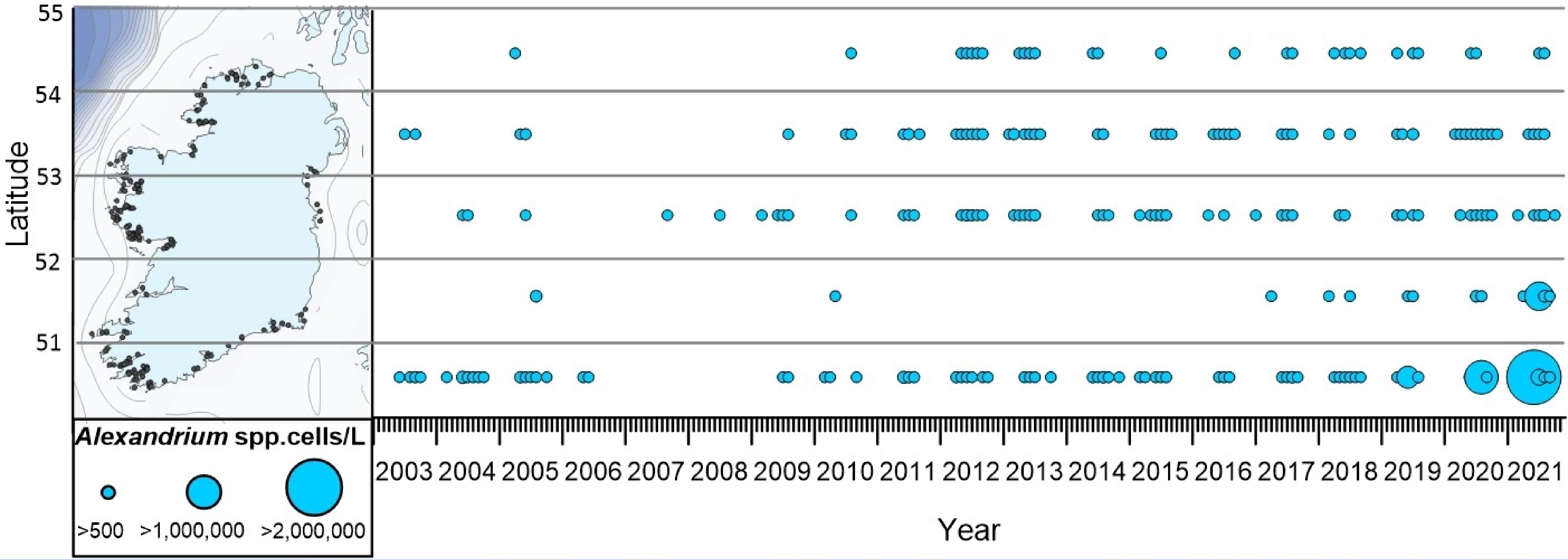

Nationally, the bloom frequency and abundance of Alexandrium has increased in the recent decade (2011–2020). In the west, small decadal average cell abundance increases occurred in June and July. In the southwest, significant increases in cell abundance occurred in the last decade between June and August, where blooms peaked in August. The significant cell abundance increases off southwest Ireland include both toxic and non– toxic Alexandrium species, with larger bloom densities observed since 2018.

Dinophysis spp. abundance and distribution

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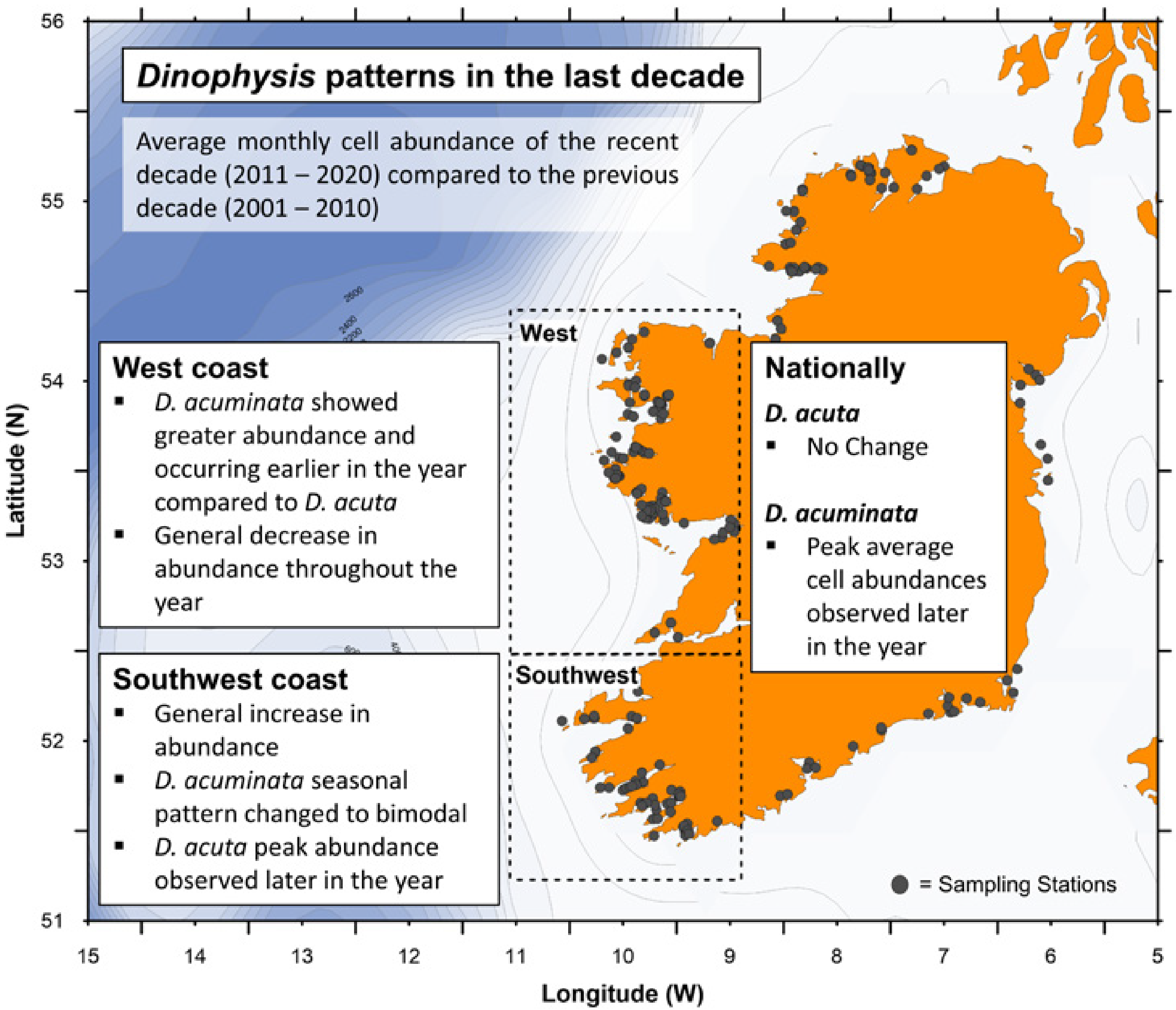
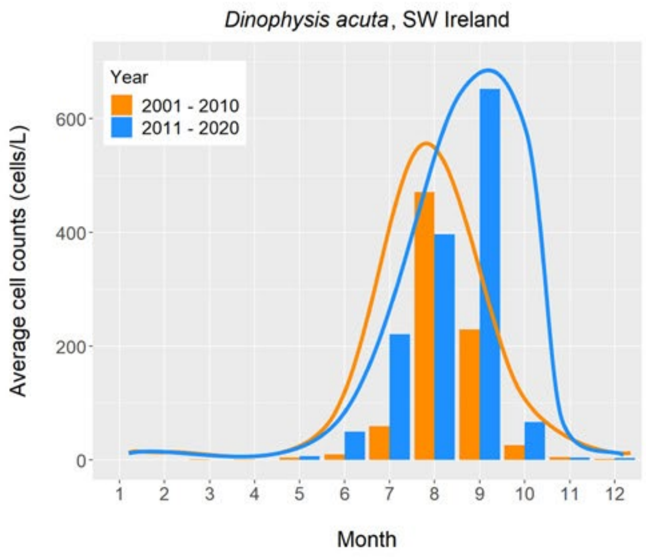
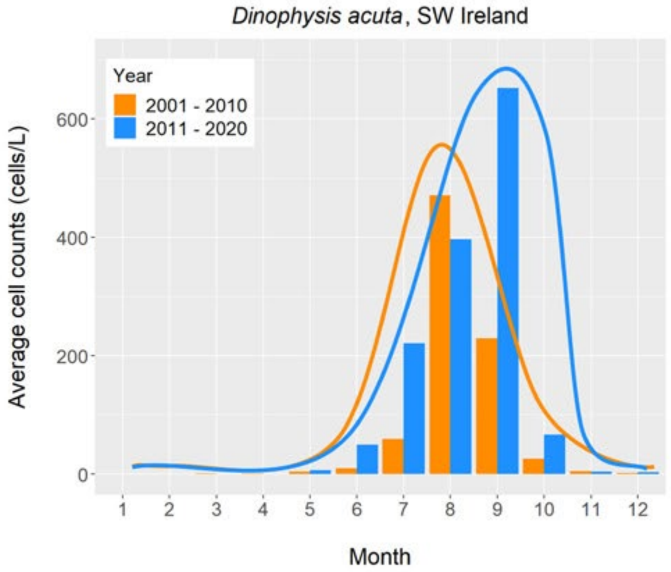
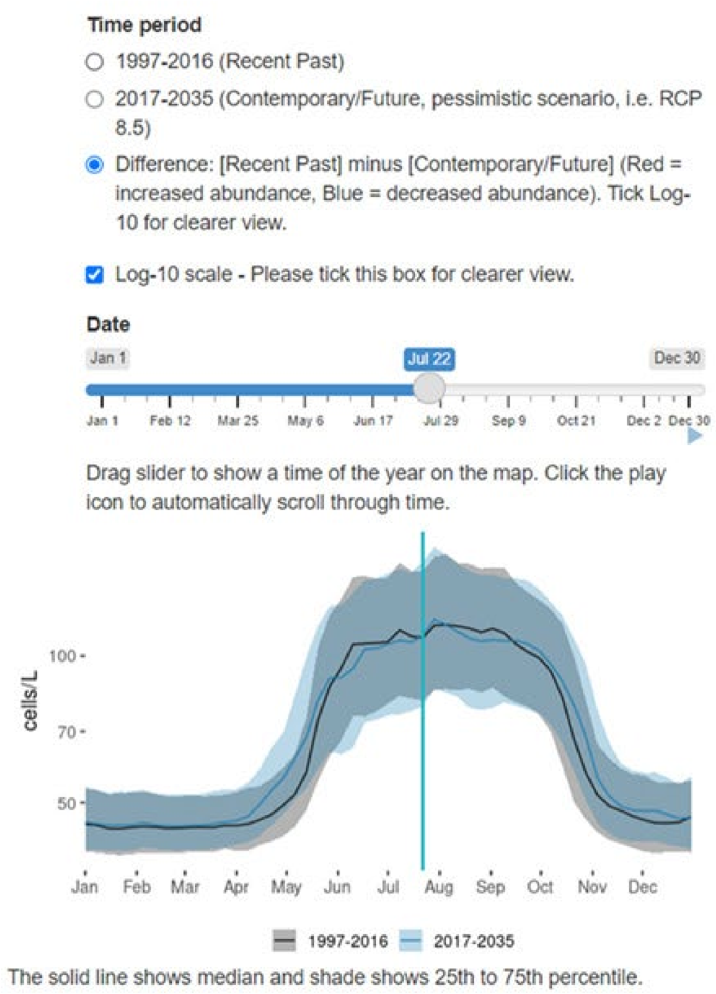
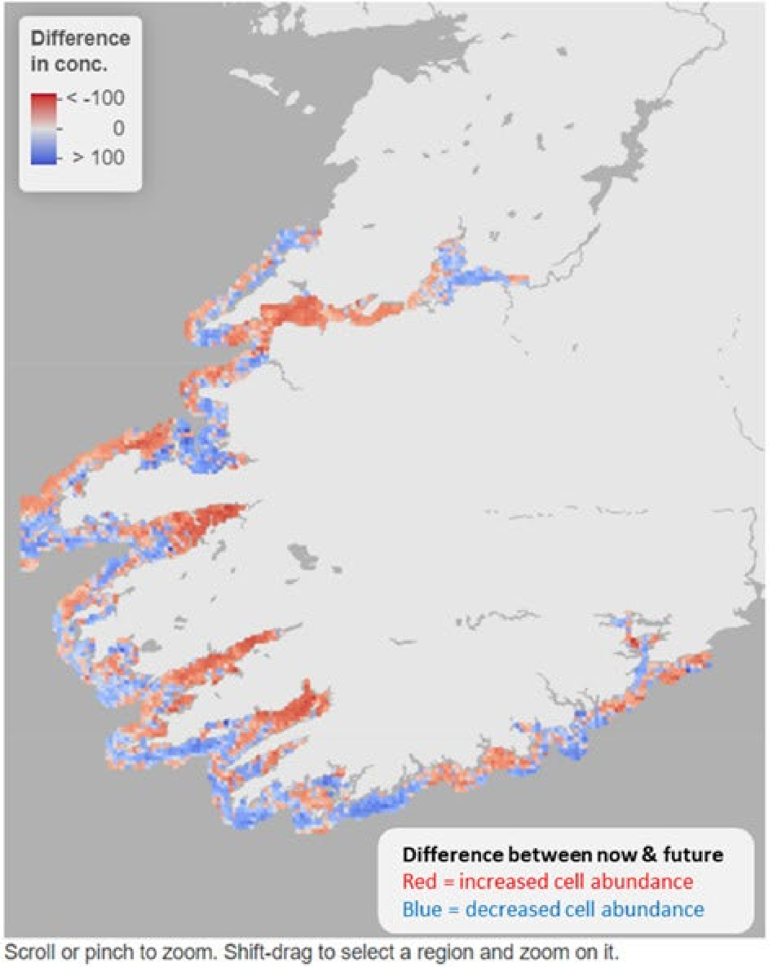






ESTIMATING HARMFUL ALGAL BLOOMS IN A FUTURE OCEAN (Case Study)





Harmful Algal Bloom Climate Service with applications developed for *Dinophysis acuminata* presence probability and abundance estimates.

A downscaled Irish ocean climate model was developed in 2020 (Nagy et al., 2021). Using data from this numerical model combined with the National Monitoring Programme HAB data, a machine learning approach was carried out to estimate future distributions and occurrences of key Harmful Algal Bloom (HAB) taxa in Irish waters.

Recommendations

1) Develop new and improved risk management decision tools to include an operational HAB forecast system and biophysical models (including the development of HAB seasonal forecasts and HAB and phytoplankton community climate predictions) that can provide support to the seafood sector adaptation plan.

2) Establish a long-term climate network of sentinel sites (collecting biological, chemical and physical data) to detect invasive plankton species and novel/ emerging biotoxins produced by these species.

3) Develop appropriate spatial scale models to estimate the future likely change in biological processes, e.g., prevalence of harmful algae.

4) Extend phytoplankton sampling offshore to improve knowledge of plankton shelf dynamics, and augment the existing alert system (HABs).

Shellfish Safety Projects - current

PSPSafe

Addressing the increasing risk of Paralytic Shellfish Toxins in Ireland focusing on Castlemaine Harbour, Co. Kerry, to identify the causes, timing, environmental factors, and mechanistic pathways of PST occurrences.

An Roinn Talmhaíochta, Bia agus Mara
Department of Agriculture, Food and the Marine

Towards an early-warning tool predicting enteric virus contamination of coastal watersheds – PREVIR

To co-develop an early-warning tool with and for coastal water users, for climate change adaptation to the contamination by enteric viruses

Water4All
Water security for the planet

Ocean CLImate variability and Phytoplankton in Irish coastal waters (Cli-PhI)

Cli-PhI will inform the development of climate change mitigation measures for the seafood sector and strategies for design of future phytoplankton monitoring programmes.

Summary & Conclusion

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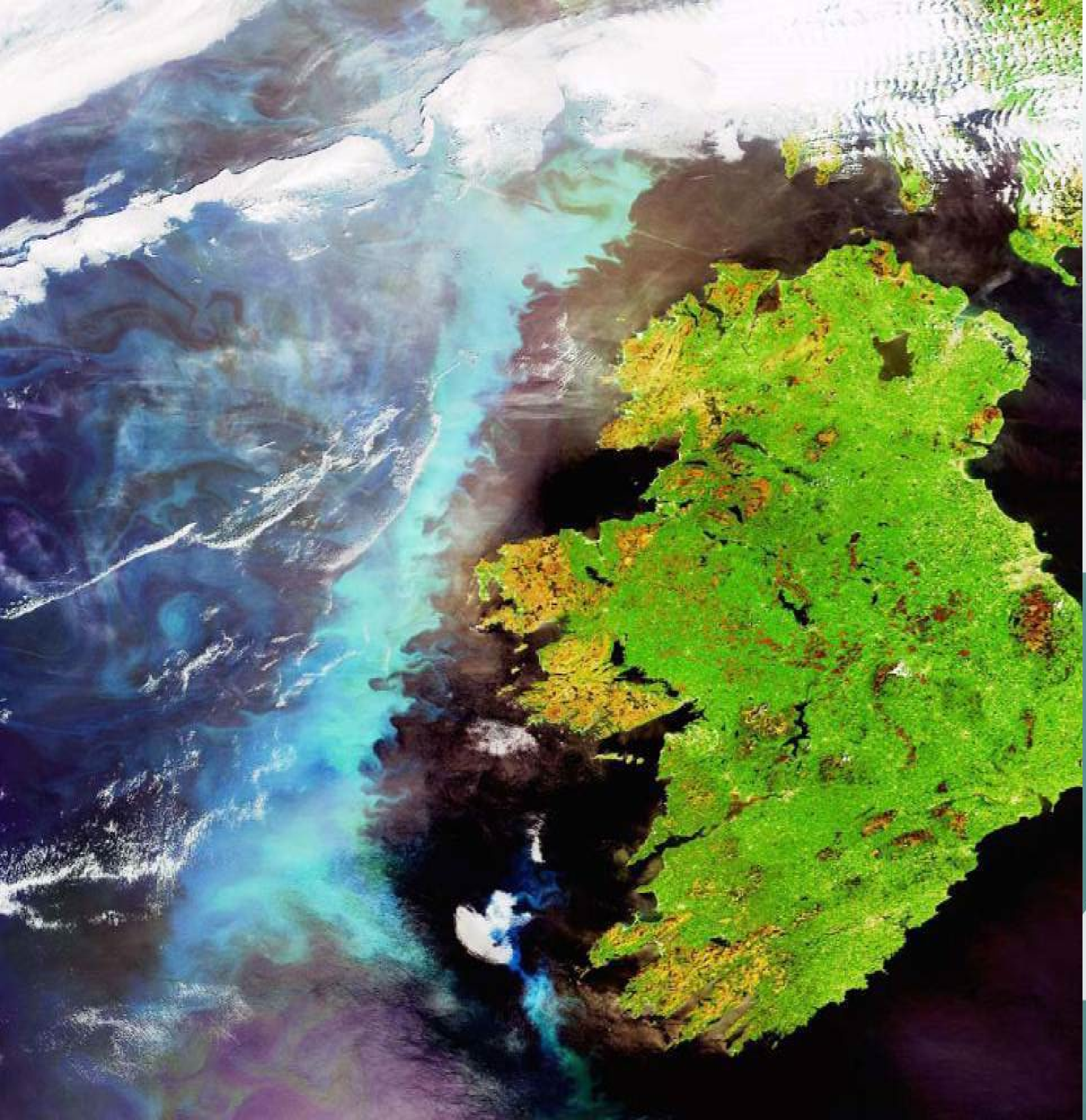
- Phytoplankton are an important food source that sustain marine life and benefit humans who depend on seafood for protein. They are considered sensitive indicators of climate change where changes in community composition can affect and alter marine ecosystems.

- Climate change impacts are a global concern with little known on how phytoplankton and Harmful Algal Bloom (HAB) species will adapt to changes in the marine environment. The impact of climate change on the seafood sector through HAB events is expected to occur more frequently in some regions.

- Studies indicate an expansion in the growth season and an increase in abundance for some species. Since 2008, the average abundance of some phytoplankton has increased in winter. In the last decade, observations show a higher average cell abundance with a more prolonged growth period throughout the year.

- Seasonal patterns of some HABs have changed. With a growing human population and corresponding demand in aquaculture production, there is uncertainty around the impact on shellfish species including settlement and growth, carrying capacity of bays, physical processes such as flooding, coastal erosion, and storm effects on coastal and intertidal habitats. Changes could also impact the timing and length of toxin-related shellfish harvesting closures.

The impacts of climate change on the seafood sector through Harmful Algal Bloom (HAB) events are expected to occur more frequently. An expansion of the phytoplankton growth season (for some species) has already been observed. Changing environmental conditions driven in part by climate change can result in multiple environmental stressors influencing HABs.



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