iFADO Case Study:
Co-development process with stakeholders.

An example of a co-development of Harmful Algal Blooms (HAB) climate service in the framework of the CoCliME project.

1. CoCliME Project

The marine-focused CoCliME project set out to co-develop user-oriented climate services to support Harmful Algal Bloom (HAB) risk mitigation and adaptation in European coastal regions. The project is implemented on four areas:

(1) Engaging stakeholders to understand their knowledge, experiences, interests and concerns;

(2) Co-developing a shared terminology and framing of the “HAB-related problems”;

(3) Advancing scientific understanding of drivers and interactions shaping HAB-climate risks and;

(4) Co-producing prototype services that integrate social and HAB-climate data and knowledge to support decision-making.

2. Advancing the science

Understanding HAB-climate linkages in the past, present and future

I. The Challenge

To anticipate future susceptibilities to HABs, the plan was to assess and co-develop adaptation services for the aquaculture industry, policy makers, and food safety regulators and build on the existing Irish operational HAB warning service to increase future resilience.

II. The Objectives

1) Identify if clear links exist between selected HABs (Dinophysis, Pseudo-nitzschia and Karenia blooms) and ambient environmental parameters using historic and modelled datasets.
2) Predict HAB dynamics under a changing environment due to the combination of climate-driven and anthropogenic forcing. Investigate if possible future changes could include a change in habitat suitability for HABs.
3) Assess possible future trends of the marine environment and co-develop climate change services, which are not yet available in Ireland.

This step in the process generates **New Knowledge**, which will feed into the co-development process.

3. HAB-climate impacts, societal risk perceptions, mitigation and adaptation strategies

HABs can threaten the aquaculture industry by causing prolonged closures of farms, loss of produce and potentially damage to reputation. It is estimated that there is ~ €530,000 loss to shellfish farmers due to HABs in SW Ireland each year. This may be exacerbated by climate change.

Bottlenecks experienced / lessons learned:

→ **Irish funding limitations restricted Ireland from carrying out an in-depth socio-economic study in CoCliME.** We have learned from the CoCliME economists working in other partner countries that socio-economic methodologies used are often bespoke to a particular region and issue (in CoCliME the HAB issues that are addressed across Europe are diverse due to the many different types of HAB taxa involved and the sectors impacted).

→ **Shellfish farmers were generally uninterested in long-term climate projections.** They wanted real-time/short-term warning information on HAB risks that can help them prepare for or avoid economic impacts.

→ **Ongoing harmful algae monitoring programmes and HAB alert systems constitute an important tool** for mitigating the societal impacts of HABs by detecting shellfish toxins, regulating shellfish closures, and preventing human health impacts.

→ **Weekly HAB bulletins (warnings) are highly used** by shellfish farmers to obtain information about current and historic closures in the area.

- → There is some concern among shellfish farmers that **weekly sampling can be insufficient** during peak bloom times since toxicity can develop rapidly in less than a week.

- → Shellfish closures that occur in winter are more damaging for farmers than those that occur in summer.

- → Shellfish farmers are most concerned about closures in wintertime since this is their main harvesting season.

- → There are potential dilemmas/trade-offs involved in choosing locations for shellfish production that have good feeding/food availability and potentially heightened exposure to HAB risks.

- → **Mitigation strategies to deal with bloom events are limited**. Even if blooms are expected, shellfish farmers' options are limited.

- → **Farmers are unwilling to relocate to areas with lower HAB risk** that do not have an influx of sufficient phytoplankton to ensure healthy/good mussel growth.

- → If future environmental conditions suggest a higher risk of HAB outbreaks and if shellfish farmers experience an increase in production area closures throughout the year, the adaptation options available to them include diversifying their livelihoods (e.g., engaging in tourism) or giving up shellfish culturing completely if they are unable to make a profit.

- → New HAB threats such as *Ostreopsis* are a potential concern.

- → Potential future adaptation responses – examples: 1) Worst case scenario: Aquaculture industry could be replaced by the tourism industry [Need to diversify local livelihoods and businesses to have a range of income options]; 2) Aquaculture businesses might be forced to think about relocating into low risk – low growth bays or changing sectors to work in tourism.

4. Integrating data and knowledge to co-develop HAB-climate services

Prototype services developed

1) Scientific data products and ocean climate model to share with researchers (intermediary service)

2) CoCliME graphics to share climate information with our downstream users (e.g., policy makers and the communities they serve, e.g., local authorities and the public).

Detailed guide based on bottlenecks experienced / lessons learned:

1. *Data availability, access, quality and integration*:

At the start of the project, an important task was to collate all available historic environmental datasets relevant to CoCliME. This is a very time-consuming activity. It was discovered that many of the available datasets did not include sufficient long term uninterrupted temporal and spatial coverage. While not ideal, we decided to use the numerical model hindcast outputs to investigate linkages with the 20-year HAB dataset for SW Ireland and used available *in situ* environmental physical data to validate the numerical model.

2. *Service focus*:

It is only through engaging with stakeholders that we can learn what our customer needs.

Scientists (mid-stream users) requested easy access to the numerical ocean modelled data. CoCliME developed a ROMS data extractor to facilitate this. Working with the users (biologists), the modellers learned the type of variables and associated data needed, the data format and how to make the data more easily accessible to the biologists.

Policy-makers (CARO) requested transparent information on where data is held and how to access it. This prompted CoCliME to develop a data management - quality management framework (DM-QMF) approach to facilitate clear and transparent information on the data flow process, documenting the standard operating procedures (SOPs) and ensuring all data generated was open access with associated DOIs.

3. *Tailoring information to meet decision-makers' needs*:

CoCliME graphics were challenging for the scientists who are not communication experts and who sometimes found it difficult to translate technical results into an easy-to-understand language for the customer. Multiple discussions (and mock-ups) within the team (MI CoCliME scientists and the CARO) and with input from other Irish ocean climate scientists and the CoCliME partners were very helpful to ensure the messages and the graphic content were clear. While co-creating the graphics with the customers took a lot of time involving numerous iterations of the text and content, this approach ensured the final graphics were suitable for the CARO needs.

4. *Data visualisation*:

Many of the CoCliME natural scientists were unaware of the importance of the colour palette choice in graphs. The modelling team initially produced result plots that were unreadable to people who suffer from colour blindness. This was rectified with help from a website tool called colorbrewer.

5. *Retaining expertise*:

Difficulties in this space negatively impact on the EP and thus on the entire co-development process

6. *Importance of cross-case collaboration*:

it is only through working with climate modellers (e.g., in this case from the UK and Sweden) that Ireland was able to develop a downscaled ocean climate model. Knowledge transfer takes time, especially when HAB scientists need climate model data output to link with the biology and apply statistical modelling methods.

7. *Climate Service - Adaptation Action knowledge Gap*:

Many CoCliME partners are applied or academic scientists who lack expertise implementing adaptive responses on the ground (local authority level). In the Irish case, a midstream climate service was peoduced in the form of ocean climate model outputs for scientists/technical representatives from state and academic institutions. The downstream service developed was information on climate change impacts on the ocean (temperature/salinity, HABs, sea level, importance of the ocean, impacts of climate change on coastal communities, etc.). It is the responsibility of the customer (CARO) to pass this information on to the relevant societal stakeholders and decision-makers. The CARO advises local and national governments on appropriate adaptation/response pathways. Note, the National Adaptation Framework is currently under development in all regions of the country.

8. *Institutional challenges connecting the research with decision making*:

Understanding the decision-making and adaptation planning process of the customers in industry and government authorities takes a lot of time. It became obvious in the later stages of CoCliME that acquiring a deeper understanding of the strategy, mandate, governing structures, activities, and decision-making processes of the customers is needed to get a better understanding of what they need in a climate service.

9. *Difficulty in transdisciplinary communications*:

the CoCliME service specification sheet development process was a time-consuming and tedious process due to the transdisciplinary nature of the project and the fact that many of the partners were unfamiliar with the process.