BLUEFISH CONFERENCE REPORT

Thursday 24th June 2021
Friday 25th June 2021

2021

Building Resilience into Blue Growth in the Irish & Celtic Seas Fisheries & Aquaculture
BlueFish

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THE BLUEFISH CONFERENCE

Climate change is already affecting the world's oceans and coasts, with European regional seas showing some of the most pronounced and rapid impacts. This has not only environmental implications, but also economic and social implications, especially for coastal communities. The consequences of present and predicted climate effects on fish, shellfish and aquaculture in the Irish and Celtic Seas are poorly understood. A combined understanding of processes and effects in the Irish and Celtic Seas will be key to ensuring increased understanding and awareness of climate change effects, and aid in sustaining blue growth throughout the region. A cross-border approach is essential to address the issues presented by changing environments and a changing climate on fish, shellfish and aquaculture activities within the Irish and Celtic Seas.

Building on the legacy, recommendations, and consortium expertise which resulted from the SUSFISH project (2009 - 2013), BlueFish aims to develop knowledge and understanding of the marine resources of the Irish and Celtic Seas, by addressing knowledge gaps regarding the effects on, and potential vulnerability of, selected commercial fish and shellfish due to predicted climate change.

Recommendations produced will support policy in building resilience for sustainable utilisation and protection of the marine environment.

The BlueFish Project brought together the Universities of Bangor, Aberystwyth, Swansea and Cork, the Marine Institute and Bord Iascaigh Mhara. It was co-funded by the Ireland Wales Territorial Co-operation Operation for the Irish and Celtic Sea, focusing on cross-border collaboration, climate change and community engagement.

This document briefly summarises the outputs of the BlueFish Project, as presented during the project's closing conference.

The BlueFish Operation would not have been possible without the funding received from the European Regional Development Fund, through the Ireland Wales Territorial Co-operation Programme 2014 – 2020. Our achievements would not have been possible without the support of several organisations cooperating with us in enhancing the marine and coastal environment, and through our engagement with coastal communities both in Ireland and Wales.

KEY FINDINGS

1 Changes in the distribution and abundance of species in response to climate change are species- and area-specific, and are dependent on historical and present dispersal, as well as habitat suitability. **Future adaptation to climate change requires species-specific and area-specific management.**

2 Plankton is one of the main **drivers of a marine ecosystem.** Continued monitoring of the changing diversity and abundance of phytoplankton and zooplankton, as well as species associated with plankton, such as *Vibrio* spp. and other potential diseases, will be important in ensuring a long-term dataset for the early detection of climate change impacts.

3 Longer-term datasets are needed to determine source-sink dynamics. It is important to identify seed source areas for juvenile fish and shellfish, particularly for vulnerable species. **These areas need to be prioritised for protection and management**, and monitored to assess any changes due to climatic and oceanographic alterations.

4 Resource stock connectivity transcends geopolitical boundaries; marine resources require cross-border management in the Irish and Celtic Seas. This must be **maintained at government level and include monitoring of environmental changes, to provide evidence and inform management** of changes in distribution of fish and shellfish stocks, incursion from non-native species, and spread of disease as a result of climate change.

5 Under current climate change predictions, the greatest impact to seabass presence and distribution is predicted from the increase in annual rainfall (and the resulting lowering of salinity in estuarine systems), which may negatively impact on the species' presence in inshore water in Ireland. **We recommend monitoring the impacts of lowered salinity in nursery habitats on the more vulnerable juvenile stages.**

6 The northward spread of the non-native Pacific oyster (*Magallana gigas*) due to rising sea temperatures is of concern. **A change in perceptions are needed to effectively manage emerging populations.**

7 **Efforts to increase the resilience of kelp habitats should be initiated** to counteract the predicted decline in kelp density resulting from climate change. These may include regulating the inputs and concentrations of nutrients, herbicides, and sediments. Likewise, an awareness of the importance of kelp detritus to coastal food webs and commercial shellfish production is needed, to inform the process of awarding kelp harvesting licences.

8 Climate change presents a major challenge for the shellfish industry; rising sea temperature and marine heatwaves increase stress and mortality of shellfish, and heatwaves are set to become more frequent and intense. **We recommend transboundary monitoring and alert systems for the spread of diseases and invasive species, surveillance of shellfish mortalities in the field, and the application of potential adaptive management solutions to prevent mortalities.**

9 Ecosystem goods and services of the Irish and Celtic Sea are a valuable resource worth an estimated €3.2 billion, providing services such as fisheries, aquaculture, carbon sequestration and tourism. **Responsible environmental management is required to have a positive impact on the economic value of marine and coastal ecosystems, with the requirement to think differently about nature for wellbeing, climate change, the marine environment, and engagement with coastal communities** - including the utilisation of art in combination with science to demystify concepts around climate change.

10 **Climate change impacts are transboundary issues that require collaboration on both sides of the Irish Sea, multi-disciplinary collaboration between governments, industry, researchers and NGOs, and cross-border partnerships.**

SESSION 1:

Welcome and Opening Statements

BUILDING RESILIENCE THROUGH SOCIAL LEARNING - Dr. Micheal O'Cinneide

Dr. Micheal Ó Cinnéide of Corrib Beo introduced resilience as the 'ability of a society or system to absorb disturbance and still retain its basic structure'. The effects of Brexit, the COVID-19 pandemic, and climate change have already tested resilience in communities bordering the Irish Sea. He highlighted the importance of learning to build resilience, in particular social learning: how communities learn to adapt to changing conditions. **Social learning is most effective when all stakeholders are engaged within a strong collaborative structure.** Within aquaculture and fisheries, this involves bringing together science, managers, and industry as collaborative partners within structures such as safety regimes, fish health programmes, and quota management. Wales and southeast Ireland have a strong tradition of collaborative projects among universities, made more valuable through engagement with local communities. He called upon these links to be maintained and strengthened.

HOW ACADEMIA CAN BETTER ADDRESS CLIMATE CHANGE - Dr. Paul Bolger

Dr. Paul Bolger introduced the changing language surrounding climate change, highlighting it continues to be a 'wicked' problem: there is no defined 'owner', no single solution, many stakeholders with competing interests, significant urgency, and a lack of central decision-making authority. He argued that **universities need to better address challenges surrounding sustainability, given their depth of knowledge.** He suggested three ways to respond:

- Crossing interdisciplinary 'valleys' by working more across academic disciplines instead of within disciplinary silos.
- Cultivating partnerships with external stakeholders, such as NGOs, communities, and industry, and bringing them into the research process.
- Creating solutions from knowledge to aid those who need it on the ground.

In Ireland, much collaboratively produced knowledge to date has faced significant barriers. This highlights the need to accelerate, scale up and build capacity for knowledge co-production.

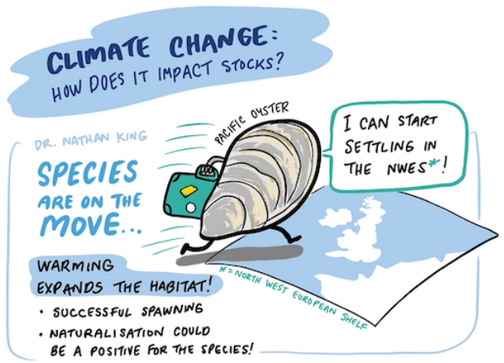
SESSION 2:

Understanding our Ecosystems and Resources

The research outputs explored in this session covered population dynamics of a number of species and how they are likely to respond to climate change. This included how the physical environment is affecting species distribution and biomass, the drivers and inhibitors of connectivity between populations, and what affects different life stages of species. It also covered the distribution and prevalence of stock pathogens, and what impacts them. All included predictions on the impact of climate change on species characteristics.

CLIMATE CHANGE WILL ACCELERATE NATURALISATION OF THE PACIFIC OYSTER - Dr. Nathan King

Originally introduced to replace dwindling native stocks, the Pacific oyster is now becoming naturalised in the northeast Atlantic (and at other sites around the world). The North West European Shelf (NWES) is a warming hotspot under climate change scenarios. As the climate warms, successful spawning is projected to increase at sites throughout the NWES and occur earlier in the year, as the species' 'thermal niche' moves northwards. Naturalisation also depends upon both dispersal and suitable conditions. The dispersal vectors most likely to enable naturalisation around the UK coast are from existing UK aquaculture sites and naturalised populations along the mainland European coastline. Possible recommendations to limit naturalisation include a transition to farming triploid (sterile) Pacific oysters to prevent escape from aquaculture, and harvesting of wild populations. There are also potential positives of naturalisation such as biogenic reef creation, especially given that native bivalves are threatened by climate change, so the Pacific oyster could represent a way to maintain wider ecosystem function.



UNDERSTANDING SCALLOP STOCKS IN THE CELTIC AND IRISH SEAS - Dr. Oliver Tully

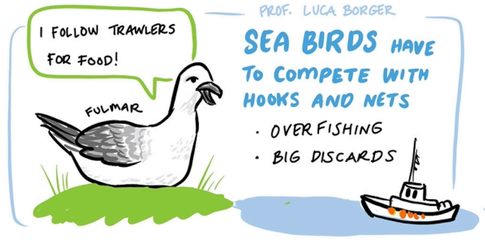
Dr. Oliver Tully explained that **scallops exist in a physically complex environment, which raises challenges for predicting the impacts of climate change.** Changes to the water column (such as through shifting frontal zones), food supply, and the seabed could all affect stocks. Through fishery-independent methods, such as dredge surveys, and fishery-dependent methods, such as catch and effort data, the distribution of scallop stocks was mapped for the Celtic and Irish Seas. Vessel Monitoring System (VMS) data highlighted 'hotspots' of activity where biomass is presumably greater. To establish biomass independent of fisheries data, researchers used acoustic backscatter, which gives a fine-scale indication of biomass in relatively small sample sites, and can be used to estimate biomass on the whole. Biological samples of landed scallops have investigated gonadal maturity, which informs seasonality within larval dispersal modelling. The datasets generated are highly useful for stock assessments, such as through informing ICES recommendations. Definitive conclusions on stock structure and connectivity are still needed for fully effective management. He recommended better collaboration between academia and the fishing fleet, to enhance the fishery-dependent datasets gathered.

EUROPEAN SEABASS POPULATIONS ARE INTERCONNECTED - Dr. Ross O'Neill

Dr. Ross O'Neill introduced European seabass as an understudied species in terms of stock structure, distribution, and connectivity. Warming waters could lead to seabass spawning further north in the Irish Sea. Small fish from six nurseries in Wales were aged through examining growth rings in their otoliths, and a particle tracking model was used to find local spawning grounds. Results indicated regional spawning using well-known spawning grounds for south Wales populations, but there was no evidence of seabass from more northern populations spawning in the south, suggesting the presence of unknown spawning grounds in the central or northern Irish Sea. Nitrogen and carbon isotopes were also used to estimate the location of feeding grounds, which indicated spatial separations between Ireland and south Wales populations. Results of metabarcoding through environmental DNA used to survey for seabass suggested it was a faster and more efficient method than morphological assessment for bulk larval analysis. DNA sequencing found that certain alleles allowed 75% of fish to be assigned to their region of origin, which could have implications for traceability of commercial products. Analysis of seabass across the northeast Atlantic suggested the presence of a single northern stock of seabass from the Bay of Biscay up the English Channel. In terms of responses to climate change, tagging studies found that seabass can tolerate significant temperature changes, but early life stages may be susceptible to the lowering salinity of nearshore and estuarine areas through increased rainfall. Populations in Irish and British waters appear more interconnected than previously thought, highlighting the need for collaborative stock management. It was suggested that future research could focus on the effects of climate change on vulnerable early life stages.

SEABIRDS INTERACT CLOSELY WITH FISHING VESSELS - Prof. Luca Borger

Prof. Luca Borger explained the aim to bring together all existing data on seabirds across the Irish and Celtic Seas. Overlaps were analysed between seabird behaviour and fishing vessel locations, with patterns varying between species and individuals. **Northern fulmar were found to closely associate with areas of intensive trawling activity,** with the distribution of fishing vessels being a stronger predictor of behaviour than environmental or climatic predictors. Vessels act as a source of food, namely through discards. There are possible implications for seabirds following reforms to the EU's Common Fisheries Policy that aim to significantly reduce discarding. A short film was made to document the team's findings and engage stakeholders and local communities, and was shown to the conference.



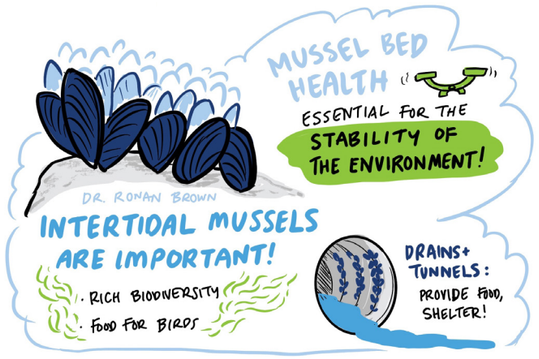
MUSSEL, SHELLFISH SEED - Dr. Ronan Browne

Ronan Browne (BIM) reported that mussels are widely distributed, economically and ecologically crucial around the coast of Ireland, and that declines in the mussel fishery have been observed over the last nine years. Their distribution on the shore is typically affected by recruitment, location, vertical height on the shore, predation, and impacts from human activity. Their overall decline is a function of predation and reduced recruitment of young mussel spat. As part of the BlueFish intertidal mussel bed mapping exercise, it became apparent that there was somewhat of an association between defunct or extinct native oyster beds and populations of mussels. Of particular interest was a correlation between existing seed mussel beds and now-vanished oyster beds in the Irish Sea. A genome-wide analysis found that *Mytilus edulis* (blue mussel) in the Irish Sea appeared genetically distinct. In contrast, populations of *Mytilus galloprovincialis* (Mediterranean mussel) and *M. edulis*, and hybrids of the two, were prevalent off southwest Ireland and showed similarities with other northeast Atlantic populations.

When studying the reproductive cycle of the intertidal mussel beds, condition index and gonad index were both measured for mussels. The latter was found to be a more precise indicator of maturity. Zooplankton samples were collected and analysed to assess the presence and distribution of bivalve larvae in

the water column. By undertaking pump suction sampling, where known quantities of water at discrete depths were sampled, it was found that there were no significant differences in the numbers of bivalves at different depths in a water column of less than 12m depth.

Another aspect of the study was establishing the influence of the zooplankton mesh size in retaining bivalve larvae. Several free-drifting drogues were released off the Irish coast to assess the potential dispersal of mussel larvae from established mussel beds. The released drogues followed different routes around the Irish Sea, indicating possible patterns of larval dispersal.



NEW PATHOGEN SPECIES AND TRENDS IN COCKLE DISEASES - Dr. Joe Ironside

Dr. Joe Ironside detailed how cockles from commercial and non-commercial sites had been surveyed for certain pathogens. Two new pathogenic protozoans were discovered: a new species of *Minchinia*, similar to *M. mercenariae*, and a new species of *Marteilia*, related to *M. cochillia* and described as *M. cocosarum*. In Irish waters, water temperature, salinity, and dissolved oxygen appeared to be the main environmental drivers of pathogen distribution. For Irish sites, *Minchinia* and *Vibrio* pathogens were found at varying prevalences, with high levels of co-infection at some sites. For Welsh sites on the other hand, no sites saw *Vibrio-Minchinia* co-infections, though both were present. While *M. cocosarum* was present at all Welsh sites, it was entirely absent from English or Irish sites. *Minchinia* prevalence was higher in the warmer seasons, suggesting infection (and co-infection) could increase with climate change. *Vibrio* DNA was found alongside cockle DNA in seabird faecal samples, suggesting that seabirds can act as carriers of *Vibrio*. Sediments also acted as a reservoir for strains of *Vibrio* known to infect cockles. For haplosporidia (such as *Minchinia*), however, neither sediment nor seabirds were established as carriers or reservoirs. This highlights the role of seabirds and the sediment in *Vibrio* life cycles, adding support to the likely complex nature of changing host-pathogen interactions under climate change.

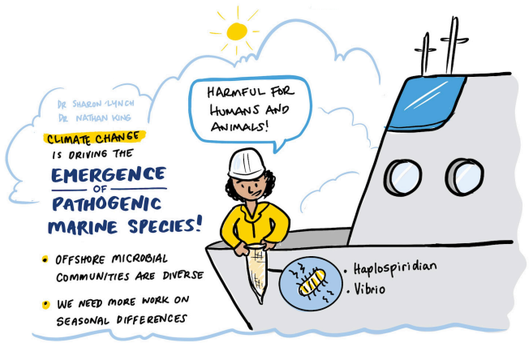
SESSION 3:

Climate and Modelling our Ecosystem

Climate models can be used to make predictions about future conditions. These can be incorporated into models assessing how species populations respond to environmental conditions, to predict how these species might be affected into the future. This includes the dynamics of invasive species and pathogens, as well as species of commercial interest.

OFFSHORE DYNAMICS OF PATHOGENS IN THE IRISH SEA - Dr. Nathan King

Dr. Nathan King described the findings of research cruises in the Irish Sea investigating pathogen dynamics, highlighting results of previous studies which indicated increasing marine pathogen abundance as temperatures increase. *Vibrio* bacteria (which can affect human and animal health) can be free-living or present in plankton or bivalves, all of which act as routes of transmission between pathogen sinks. Samples of sediment, water, and plankton from different points in the Irish Sea used a new molecular technique to characterise bacteria presence and abundance. *Vibrio* abundance was consistently low in May, but high in September in plankton samples, as plankton abundance increased. Plankton composition also differed, constituting almost entirely copepods in September, which may contribute to pathogen abundance to some degree. Stratified waters generally led to low bacterial diversity, but not for *Vibrio*, which appear to thrive in hostile environments. Results suggested that **zooplankton samples were the most effective sample type for monitoring emerging pathogens,** and it was recommended that monitoring for emerging pathogens continued.



FRONT COMMUNITIES - Katie Coestello, Dr. Sharon Lynch & Prof. Sarah Culloty

Dr. Sharon Lynch explained the bacterial surveys conducted in the Celtic Sea in May (similar to the Irish Sea surveys, above). While nearshore environments are relatively well monitored, less is known about offshore environments - which will be important for potential future aquaculture activity. High planktonic diversity was found, especially in the Celtic Sea Front (supported by high productivity). The southern Celtic Sea had much lower diversity, perhaps due to climate change instigating northward migrations. Molecular techniques detected low levels of the shellfish pathogen *Vibrio splendidus* in the Celtic Sea Front, and higher prevalence in the southern Celtic - an inverse relationship to biodiversity. **The Irish Sea and southern Celtic Sea have very different bacterial community profiles, possibly due to temperature differences.** More work is needed to classify bacteria at the species level and decipher what drives abundance, to be able to monitor emerging pathogens.

NICHE MODELS AND REAL-WORLD SPECIES CHANGES - Prof. Paul Shaw

Prof. Paul Shaw explained how species niche modelling was combined with projected future climatic changes to predict where species will occur and become more or less abundant in the future within the study region (Irish Sea and Celtic Sea). Four main responses to changing environmental conditions were found, depending on the species:

- Species track their preferred water temperature northwards - predicted for seabass, for instance.
- Abundance increases within current range as conditions become more favourable - predicted for Mediterranean mussel, for instance.
- No substantial change in abundance or distribution - predicted for blue mussel, for instance.
- Species distribution does not change, but abundance decreases in the southern parts of the range - predicted for great scallop, for instance.

It was emphasised that models are a blunt tool, and **models need to be matched to current species traits to gauge their accuracy.** Seabass were chosen to assess the relationship between modelled and real-world changes. Generally, southern seabass populations are resident, while northern populations are migratory. Seabass in the Irish Sea are showing increasing 'resident' behaviour, but were found to be genetically distinct from populations off the Portuguese coast. This suggests that climate change is changing the breeding habits and dynamics of the existing Irish Sea stock, rather than instigating a northwards shift of the whole species. Concluding recommendations highlighted that different species respond differently, and their responses are affected by local environmental conditions within broader regions (such as the individual hydrodynamic conditions of the Irish Sea, which differ from the general state of the wider NE Atlantic area), indicating a need for species-specific research and cross-border management regimes.

THE CELTIC SEA FRONT AND LARVAL DISPERSAL PATTERNS: PRESENT AND FUTURE - Dr. Sophie Wilmes

Dr. Sophie-Berenice Wilmes investigated the role of the Celtic Sea Front (CSF) in driving shellfish population connectivity across the front. From early summer, the CSF separates seasonally stratified waters in the Celtic Sea and Celtic Deep from fully mixed waters in the Irish Sea. At present, larval behaviour in larval dispersal models is often derived from tank experiments in laboratories; these swimming behaviours result in models where larvae are generally dispersed at the surface of the water column. However, in-situ measurements of bivalve larvae in the ocean report the highest larval concentrations associated with the thermocline. For dispersal scenarios with larvae at the surface, larvae are transported across the CSF into the Irish Sea. Where scenarios have been run with larvae at depth (15m - 30m) this showed that the CSF represented a barrier, preventing the dispersal of larvae into the Irish Sea from the Celtic Sea; however, there was dominant transport of larvae along the CSF at this depth, with the transport pathway from south Wales to southeast Ireland. These arguably more realistic scenarios correspond with breaks in mussel sub-populations and scallop genetics between the Celtic Sea and the Irish Sea. More data on real-world larval behaviour is needed to fully constrain larval dispersal models. An ocean model of future ocean changes suggests that the CSF may shift northward into the Irish Sea, thus weakening any barrier function the CSF has at present. However, these results need to be cautiously interpreted, as the present-day frontal location in the model is too far northward.

PARASITES AND PATHOGEN RESERVOIRS IN WILD SHELLFISH - Dr. Christopher Coates

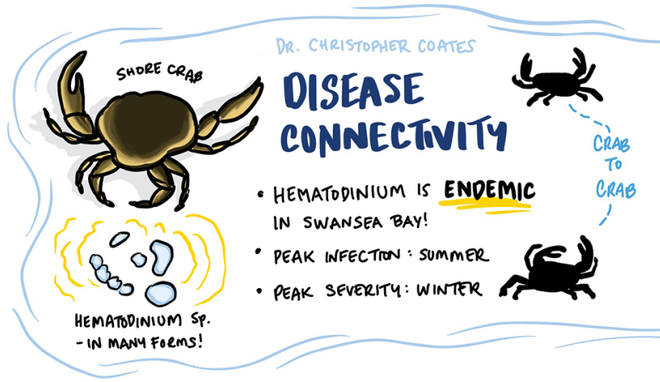
Dr. Christopher Coates discussed the role of shore crabs as reservoirs of disease for commercial species such as edible crabs and Dublin Bay prawns. *Hematodinium*, a parasitic dinoflagellate genus, was examined in well-established populations of shore crabs in Swansea Bay. Through biometric, cellular and molecular measurements of infection, *Hematodinium* was found to be endemic in ~14% of shore crabs. Infection prevalence was greater in spring and summer, but parasite loads were lower compared to autumn and winter, when fewer crabs were infected but to a greater degree. Environmental screening found no evidence of transmission from zooplankton, with horizontal transmission between crabs the most likely source of infection. Males were twice as likely to be infected, and smaller animals were also more likely to be infected, which is attributed to their higher frequency of moulting, when they are vulnerable to infection. Parasitic haplosporidia were also assessed and two new species discovered in shore crabs. Infection with *Sacculina carcini,* a parasitic barnacle, was found to be under-reported if only traditional external measurements were taken. Overall, it was established that **shore crabs act as a refugium for many parasites and pathogens, with infection characteristics influenced by their environment more than host genetics.** It was recommended that a systematic approach to disease surveying was needed to generate long-term datasets that can shed light on the impacts of climate change on disease characteristics.

SPREAD OF INVASIVES AND PATHOGENS VIA PORTS - Dr. Sharon Lynch & Prof. Sarah Culloty

Given the role of shipping in introducing invasive species and their associated pathogens, a horizon scanning exercise was conducted for Irish ports. Three species of invasive crab - Chinese mitten crab, Asian shore crab, and brush-clawed crab - and potential routes for introduction via ballast water and hull fouling were investigated. The species are already established in many European ports, with ports in the Netherlands and Germany posing the highest risk for introduction to Irish ports. In January 2021, berried Chinese mitten crabs were observed in Waterford Harbour, indicating it had established a breeding population. This species is a predator, causes physical destruction to the environment, and is a carrier of crayfish plague which threatens the native white-clawed crayfish. **To control the introduction of invasives and associated pathogens as much as possible, there is a need for integration between parasitology and invasion ecology, and heightened screening and surveying** (such as through citizen science). Climate change will change invasive dynamics, and horizon scanning can help predict these changes.

INVASIVE SPECIES AND AQUACULTURE PATHOGENS - Dr. Sharon Lynch & Prof. Sarah Culloty

Invasives and their associated pathogens have economic, environmental, and health impacts. Interactions can vary: invasives can reach new areas without their native pathogens, giving them a competitive advantage; their pathogens can infect susceptible native hosts; and invasives can provide a reservoir for native pathogens, increasing pathogen prevalence. Climate change will affect all these relationships, which will necessitate a change in management structures, such as the introduction of temperature-based disease surveillance models. A number of Irish sites were screened for three species of invasive tunicates which harbour pathogens that can infect commercial species such as oysters. Two of three pathogens detected in native and Pacific oysters were also found in invasive tunicates. Invasive tunicates can therefore act as a sink for native pathogens, amplifying infection of native species. In two sites in Wales (one involving native oyster restoration and one with commercial activity), invasive slipper limpets were screened for pathogens. They were found to not be susceptible to *Vibrio* infection, so were not a sink for bacterial infections of native species, though they had a negative effect on natives through other effects such as stacking on bivalves. Research overall indicated that invasive species are becoming an increasing threat with climate change, and more research is needed to understand species-specific interactions. eat with climate change, and more research is needed to understand species-specific interactions.



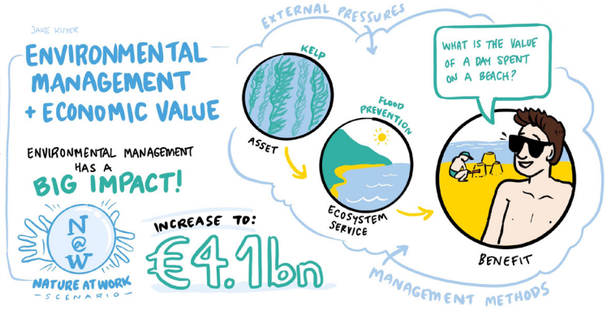
SESSION 4:

Climate Ecosystem Goods & Services and Blue Growth

Marine and coastal ecosystems perform fundamental life-support services critical to society, including provisioning (goods produced or provided by ecosystems), regulating (benefits from regulation of ecosystem processes), cultural (non-material benefits from ecosystems), and supporting services (factors necessary for supporting ecosystem function). These ecosystems are increasingly under threat from widespread and growing pressures on marine and coastal resources. Improved understanding of the importance and value of coastal and marine ecosystems to humanity could help inform decisions and influence behaviour, such as conserving ecosystems to enhance resilience of coastal communities to climate change.

ECOSYSTEM GOODS AND SERVICES: IDENTIFICATION, ECONOMIC VALUE, AND CLIMATE SCENARIOS – Dr. Paul Connolly

Dr. Paul Connolly outlined the key ecosystem goods and services of the Irish and Celtic Seas, which are worth an estimated €3.2 billion to Irish and Welsh coastal communities. This included provisioning services, such as fisheries and aquaculture, regulating services, such as carbon sequestration, and cultural services, such as tourism. Tourism in fact accounted for the most significant proportion (43%) of total value. The economic impacts of climate change on these goods and services were assessed under three scenarios. A 'business as usual' scenario, where economic development follows current trajectories and priorities remain the same, predicted that values would remain stable in 20 and 50 years' time. A 'nature at work' scenario, where the environment is prioritised and aided by technological innovation, predicted an increase in value. A 'local intensification' scenario, which prioritises local self-sufficiency and where there is increased demand on environmental resources, predicted a decrease in value. This indicated that **responsible environmental management can have a positive impact on the economic value of marine and coastal ecosystems.** Stakeholder engagement was severely disrupted as a result of Brexit and the COVID-19 pandemic. Furthermore, the pandemic has introduced new ways of thinking on the role and nature of work, work-life balance, and wellbeing. Society in general, and coastal communities in particular, are much more aware of climate change and the ocean. This presents a great opportunity to engage with them using the outputs of BlueFish. In the coming years, coastal communities will not only have to deal with the impacts of climate change, but also with the rapidly emerging marine policy areas of biodiversity loss, sustainable development, Marine Protected Areas and Marine Spatial Planning. The transfer of knowledge to stakeholders will critically inform the debate on these new policy areas, and the economic impact on the livelihoods.

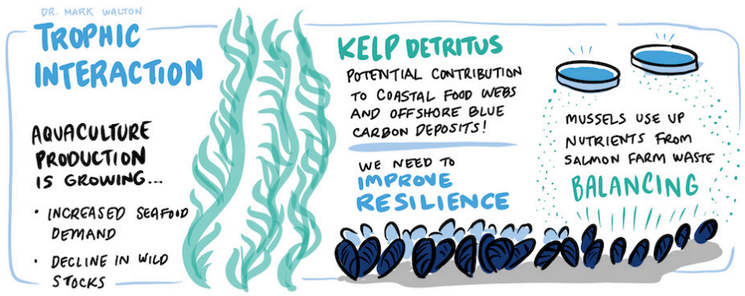


ECONOMIC IMPACT OF MARINE ENVIRONMENTAL MANAGEMENT: AN ECOSYSTEM GOODS AND SERVICES APPROACH – Jake Kuyer

Jake Kuyer explained that the framework of ecosystem goods and services provides a means of measuring the benefits which ecosystems provide in economic terms. Environmental assets ('natural capital') provide flows of ecosystem services, which can also require inputs from other capital to be utilised - for instance, benefiting from healthy fish populations for sustenance relies on fishing boats. Economic valuation can include easily quantifiable aspects (market goods and services), such as income from fishing or tourism, while others (non-market goods and services) are more difficult to quantify, such as carbon sequestration or recreational use, though they can still be given an indicative monetary value. External pressures (e.g. climate change) can negatively affect the value of goods and services, while good management practices can increase them. A literature review of ecosystem goods and services in the marine environment helped to collate values in accessible infographics, though there were gaps in existing evidence. Scoped ecosystem services, such as aquaculture and wild capture fisheries, were assigned monetary values through evidence from the literature and modelling, and adjusted to the area and various assumptions. Baseline results had differing degrees of certainty, but give an indication of the values of ecosystem goods and services for Ireland and Wales' marine resources. Modelling using the same three scenarios as the previous presentation showed projections for different ecosystem services, based on expert judgement and existing evidence. There are caveats due to assumptions and uncertainty surrounding climate change and future impacts; nevertheless, there remains a strong economic basis for environmental management.

TROPHIC INTERACTIONS OF AQUACULTURE IN BANTRY BAY – Dr. Mark Walton

Dr. Mark Walton described integrated multi-trophic aquaculture as a method of reducing the environmental impacts of aquaculture, through co-location of organisms with different trophic levels - such as fish, bivalves, and seaweed - so that the waste products of one level are utilised by another. Bantry Bay hosts both salmon and mussel farms. Isotopic analyses suggest that mussels in the bay receive the majority of their nutrients from kelp detritus, some from phytoplankton and a small amount from salmon feed, especially those closer to salmon cages. While the mussels only directly ingest a small proportion of the particulates released from the salmon farm, the amount removed by annual mussel harvests balanced these releases. Modelling showed the carbon released as detritus by kelp, was equivalent to that fixed by phytoplankton and far exceeded the amount required by the mussels cultured in Bantry Bay. However, when chlorophyll concentration is low at certain times of year, the mussels rely more upon kelp detritus. This highlights the likely importance of kelp for mussel diets. Moreover, as these mussels only consume ~1% of the kelp production, kelp detritus is likely to play an important role in providing tropic subsidy to other habitats and may be a significant source for offshore blue carbon pools. Declines in kelp from direct human impacts and climate change are therefore concerning, so management should incorporate kelp conservation or restoration to build resilience.



SESSION 5:

Climate and Coastal Communities

The BlueFish project's engagement with local stakeholders and coastal communities is an important theme to connect project outcomes with the people they directly affect. The aim is to educate local stakeholders about the impacts of climate change on coastlines, communities, and key marine industries, such as fisheries and aquaculture.

COMMUNITY COOPERATION, CLIMATE CHANGE, AND OYSTER HEALTH – Dr. Nathan King

Disease-induced summer mortalities represent one of the biggest constraints to bivalve aquaculture across the world. In Ireland, oyster farming is growing at a rate of ~2% per year, employing around FTE 541 people (2020). As part of this exercise, BIM was provided with assistance from businesses and individuals at sites across southern Ireland of oysters, seawater, sediment, other bivalves, and physicochemical characteristics. The Irish Sea currently sits at a threshold temperature in summer for a number of known pathogens, and it is anticipated that mortality events will become an increasing problem as temperatures increase. Through effective collaboration with BIM, Bangor University, and a number of local stakeholders, an extensive pathogen surveillance program was undertaken over two consecutive years at oyster farms throughout Ireland. During this program, distinct blooms of *Vibrio* bacteria occurred, with one in summer 2019 coinciding with a mass mortality at one shellfish farm. The surveillance program identified the disease-causing bacteria as *Vibrio aestuarianus*. This site also suffers from high nutrient loading, which is a known mechanism to reduce oyster resilience to pathogens resulting in mortality.

DEMYSTIFYING CLIMATE CHANGE: ART AND COASTAL COMMUNITIES – Sharon Sugrue

Sharon Sugrue explained how **art in combination with science can be used to demystify the concepts surrounding climate change** with local communities and stakeholders. Artwork was commissioned to depict schematics, key iconic fish and shellfish species, the changing climate and its effects on the Celtic and Irish Seas and coastal infrastructure, and context for quotes from local people, fishermen, restaurateurs, and local businesses. In combination with other media, this portfolio of work has been used extensively in stakeholder engagement and outreach, such as through interviews, magazine articles, workshops, and festivals.

DEMYSTIFY: THE BLUEFISH ANIMATION – Felicity Donnelly

Felicity Donnelly recounted how plans for a BlueFish Exhibition tour of coastal communities were interrupted by the COVID-19 pandemic from March 2020. To find alternative ways to share the portfolio, a bespoke BlueFish animation entitled 'Demystify: linking art and science to demystify climate change' was created. This animation consolidates and presents the full collection of the BlueFish artworks and infographics and aims to link art and science, to demystify what is meant by complex climate change scenarios and to promote a wider understanding of impacts to coastal communities in Ireland and Wales. 'Demystify' follows the story of Frank, an ordinary character in a coastal setting who is initially confused and frustrated by changing unseasonal weather conditions. The viewer follows him through the demystification process to the moment of realisation that everything is linked; one change impacts another, and we must all act collectively to build resilience to the impacts of climate change. The animation and an accompanying compendium are due for public release in autumn 2021.

SESSION 6:

Climate Change

DEPUTY MINISTER'S ADDRESS ON TACKLING CLIMATE CHANGE – Lee Waters MS

Approaches for tackling climate change from a policy perspective were detailed by Lee Waters MS, Deputy Minister for Climate Change in Wales. Lee Waters MS highlighted the establishment of the new Welsh Climate Change Ministry, which will bring together portfolios on the environment, energy, housing, planning, digital technologies, and transport, to integrate policy solutions using a holistic and climate-friendly approach. Working collaboratively across political boundaries, particularly the Irish Sea, and engaging communities in sustainable development and nature-based solutions, will be critical for addressing the climate crisis.

SESSION 7:

Panel Session

The panel discussion centered around the changing realities and uncertainties of future funding mechanisms, Brexit, and the COVID-19 pandemic. Possible sources of funding were identified as EU and UN initiatives, SCoRE Cymru, Horizon Europe, and Ocean Mission. Establishing a forum to maintain the strategic linkages between Ireland and Wales, forged through BlueFish collaborations, would provide an interim solution and ensure project partners continue to work together. Despite future uncertainties, partners should continue to promote and share their work with scientists, policy makers, and coastal communities.

Glossary

Biomass - the total quantity/weight of organisms in a given area.

Dinoflagellate - a type of single-celled organism, commonly found in marine plankton.

Drogue - a device usually used to improve vessel stability, that can also be set adrift to track ocean currents.

Frontal zone - a boundary between two bodies of water with different characteristics, often with high nutrient concentrations.

Gonad - an organ that produces eggs or sperm, or other reproductive gametes.

Haplosporidia - a type of protozoan that typically parasitises invertebrates.

Intertidal - the area of a seashore between the high tide and low tide marks.

Invasive - typically, an introduced species that negatively affects its new environment.

Isotope - different varieties of an element with the same chemical properties, that can be used to 'fingerprint' samples - such as identifying a place of origin.

Metabarcoding - the identification of many different organisms or species within a single DNA sample - for instance, a sample of seawater which contains environmental DNA.

Naturalisation - the introduction of an organism to a new region.

Pathogen - a disease-causing microorganism.

Population dynamics - a type of mathematics used to model populations, such as size and age compositions.

Protozoan - a large group of single-celled organisms.

Water column - a conceptual column of water from the surface to where it reaches the sediment, used to describe differences in environmental properties at different depths.

ILLUSTRATIONS BY LAURA SORVALA
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