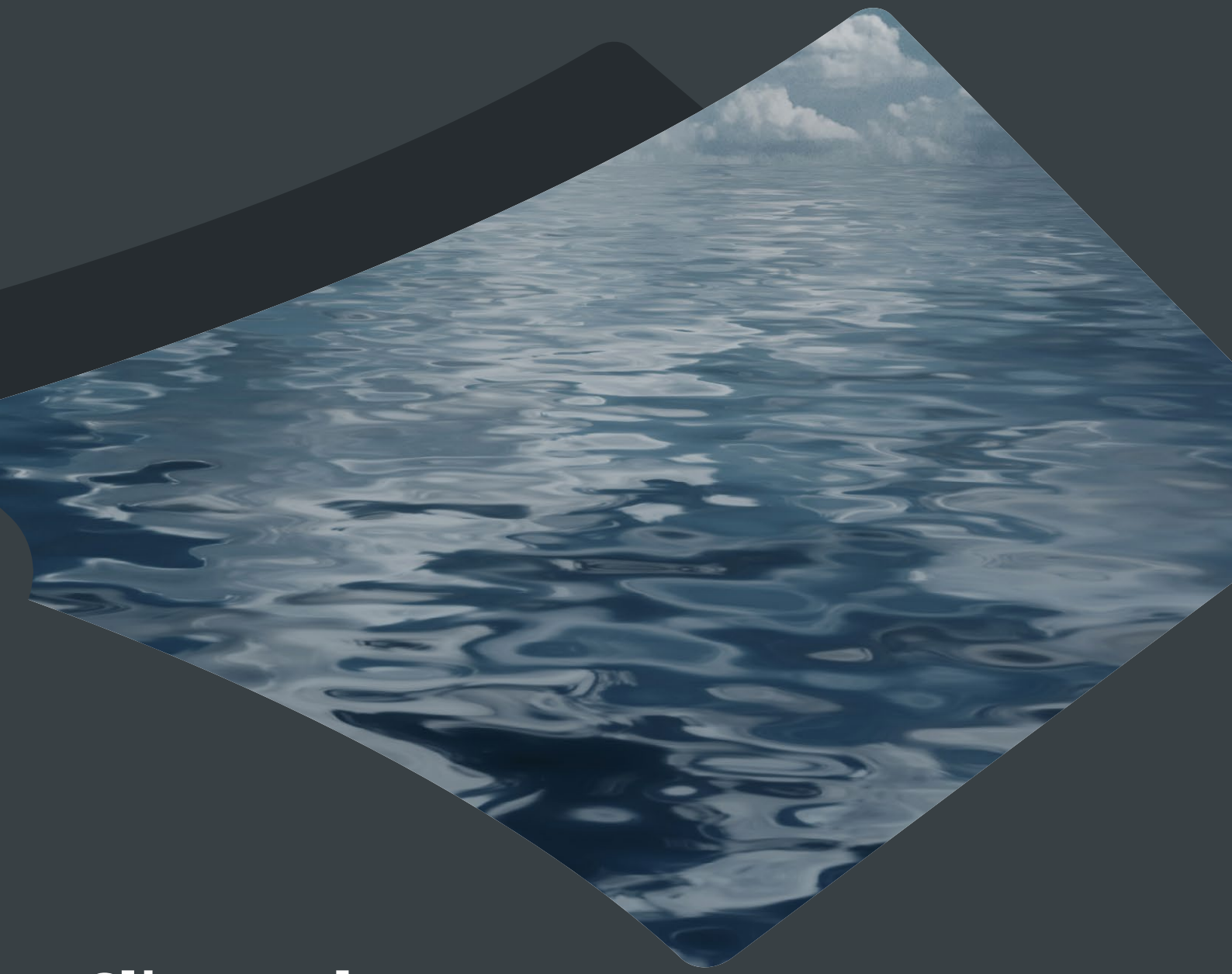
Seafood Strategic Outlook

March 2021



Climate change adaptation in UK seafood:

understanding and responding to climate change in aquaculture sourced seafood

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Introduction

This summary report explores climate change adaptation in the UK seafood industry with a particular focus on aquaculture sourced seafood from domestic and international locations. It highlights some of the major impacts on the industry, from production to processing, that arise from key climate change drivers and provides examples of major areas where adaptation action may be required.

This exercise conducted in 2018/19 aims to support the UK seafood industry to develop a managed adaptive approach to climate change. This document:

- Summarises projected climate change impacts with implications for aquaculture sourced seafood.
- Identifies relevant seafood industry adaptation responses (these responses will rest with industry bodies and others to take forward).

Several longer-term developments including climate change, ecological constraints, globalisation and human population changes (growth and tastes) influence the global food system. With increasing volatility in weather, and wider changes in environmental conditions, the importance of *climate change* is increasing and is now much more embedded in the policy agenda.

Climate adaptation is therefore a strategic challenge facing the industry. Climate change developments are likely to affect nearly every part of the seafood industry (from production to consumption). Such developments may be negative but could also be positive.

This document focusses on impacts of climate change across the supply chain: capture / broodstock cultivation; hatching and nurseries; farming, harvesting, and slaughtering; processing and storing; and transport and distribution. It covers the key commercially traded aquaculture species relevant to UK seafood: salmon and trout; bivalve shellfish; seabass and seabream; pangasius and tilapia; and warm water prawn. This work does not cover market/sales outlets, consumption and waste.

The report has been produced by Seafish in collaboration with the Scottish Salmon Producers Organisation (SSPO), Stirling University and Cefas with input from across the industry. The exercise relied on research evidence and industry experience (engaging around 30 stakeholders). Stirling University and Cefas contributions are courtesy of two EU Horizon2020 research and innovation projects exploring the impacts of climate change and seafood; *Climefish* and *Ceres* respectively. The full report was submitted to the UK Government under the Climate Change Adaptation Reporting Power and is available from Seafish.

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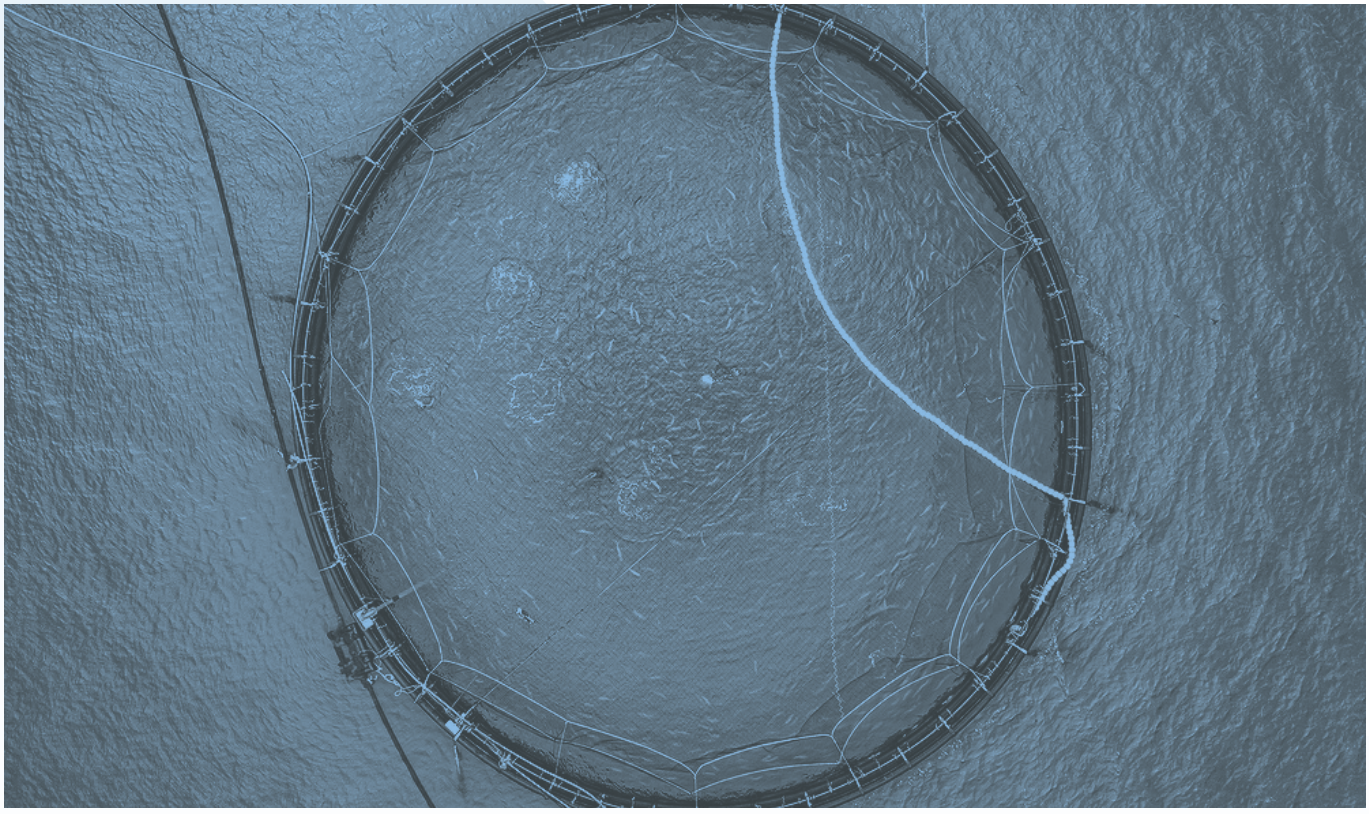


1. UK seafood industry

The UK seafood system, being reliant on raw material from aquaculture production and wild capture, is diverse, complex, and dynamic. The seafood industry is considered here to operate as many subsystems (regional, sectoral), of varying degrees of interdependence, nested within one overarching global system.

In the global context, from a UK perspective, there are at least two major seafood systems with distinct characteristics:

- A domestic system – *seafood reliant on domestically sourced material (material farmed in the UK, material caught from North Atlantic stocks and landed in the UK).* Within the 'domestic system', the key UK actors are: producers (farmers/vessels), agents and merchants in the UK handling material landed/ farmed in the UK; seafood processors located in the UK; and the downstream supply chain in the UK of all the former including food service companies, retailers and exporters.
- An international system – *seafood reliant on internationally sourced material (material farmed outside the UK, material caught from stocks in the North Atlantic and elsewhere landed outside the UK).* Within the 'international system', the key UK actors are agents and merchants in the UK importing fish and shellfish that is caught/landed/farmed and possibly processed outside of the UK; seafood processors of imported fish located in the UK; and the downstream supply chain in the UK of all the former including food service companies, retailers and re-exporters.

It is notable that from a UK perspective, seafood material is generally imported for UK consumption whilst material originating in the UK is largely exported for overseas consumption. The UK consumer maintains a robust preference for salmonids (farmed salmon), whitefish (wild caught cod, haddock and Alaska pollock), pelagics (wild caught tunas) and shellfish (wild caught cold water prawn and farmed warm water prawn). Meanwhile, volumes of UK wild caught seafood are dominated by mackerel and herring (pelagics), Nephrops (shellfish) and cod and haddock (whitefish) whilst UK aquaculture production is dominated by farmed salmon (salmonids) and cultivated bivalve molluscs - predominantly mussels and oyster species (shellfish).

This exercise is concerned with seafood derived from aquaculture recognising there are some dependencies on wild capture (as an input into feed ingredients) - see Fig 1.1. Being a food producing resource with close interplay with the natural environment, there are inherent uncertainties facing aquaculture production systems. In general, the UK seafood industry does not tend to think far ahead, in dealing with day-to-day realities, in highly uncertain conditions, particularly in wild capture. In contrast, aquaculture operators can adopt a slightly longer-term time horizon; for example, investment in new sites and offshore and land-based systems can exceed five years.

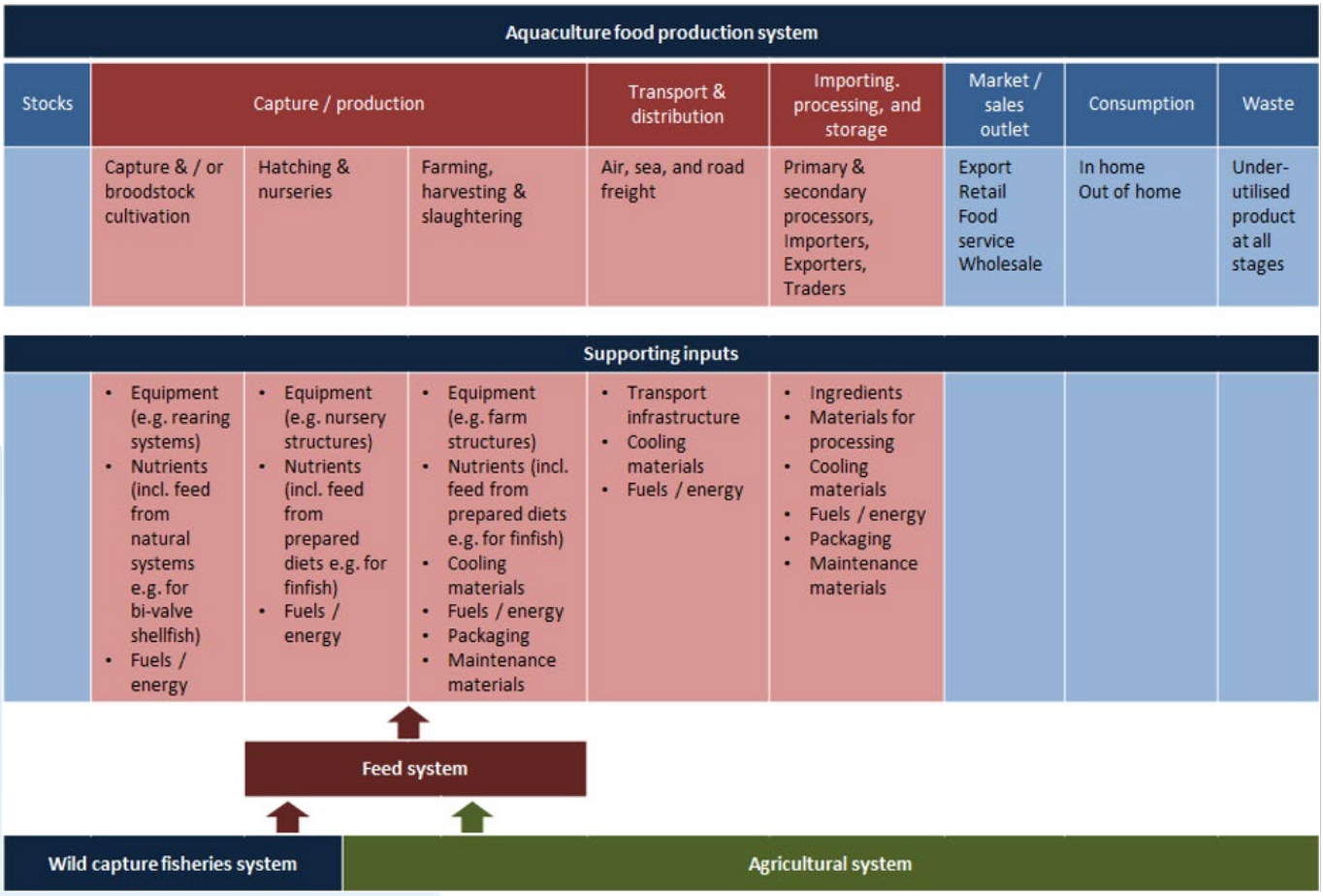


Fig 1.1Generic aquaculture food production system with supporting inputs and related systems (report boundary in red)

2. Climate change background

Summarising the main impacts on the UK seafood industry relies on what has been observed (by scientists) and what is experienced on the ground (by industry).

Science perspectives

At a global level, the most authoritative source of information on global climate change continues to be the Intergovernmental Panel on Climate Change (IPCC) and its periodic assessment reports. At the UK level, the Marine Climate Change Impacts Partnership (MCCIP) has been collating scientific evidence on coastal and marine climate change impacts since 2006. Both sources, and recent climate change work by the United Nations Food and Agriculture Organisation (FAO), have been drawn on.

Five principal climate change drivers are relevant to understanding potential impacts on seafood. Some of these are generating impacts now (the current generation), some expected to impact by 2040 (the next generation) and some by 2070 (the generation after next). These are:

- **Changes in storminess and waves.** Impacts of this are *happening now* e.g., increased damage to port infrastructure and affecting safety (and time) on the water.
- **Air and water temperature change.** Impacts of this are *happening now* e.g., changes in sea temperature are already affecting some wild caught species and might yet affect the range of farmed species.
- **Changes in terrestrial rainfall.** Impacts of global changes in rainfall *may be seen by 2040* e.g. surface flooding of land-based infrastructure and affecting water quality and salinity of nearshore waters.
- **Sea level rise.** The significant problems of extreme water levels *may be seen by 2070* e.g., increasing the risk of coastal flooding of onshore infrastructure.

- **Ocean acidification and de-oxygenation of water** is less certain, but impacts *may be seen by 2070* e.g., affecting fish in low oxygen waters and shellfish where acidification affects their ability to form shells.

and for feed systems:

- **El Nino; the frequency / severity of el Nino events.** This climatic event is *happening now* and is relevant as a particular driver of interest for aquaculture feed and ingredient production.

Main implications for the seafood industry

These drivers impact on the industry, both domestically and internationally. Effects are expected to be experienced across aquaculture (marine and freshwater / brackish waters), feed ingredients from capture fisheries (marine related aspects of the feed system), onshore aquaculture production as well as transportation and processing.

For domestic aspects, locality means there is a finer level of detail available regarding local production and operating conditions. International aspects are necessarily more opaque, so a greater emphasis is placed on broader scale regional patterns.

Climate change observations suggest a range of implications for both domestic and international aspects of the UK seafood industry:

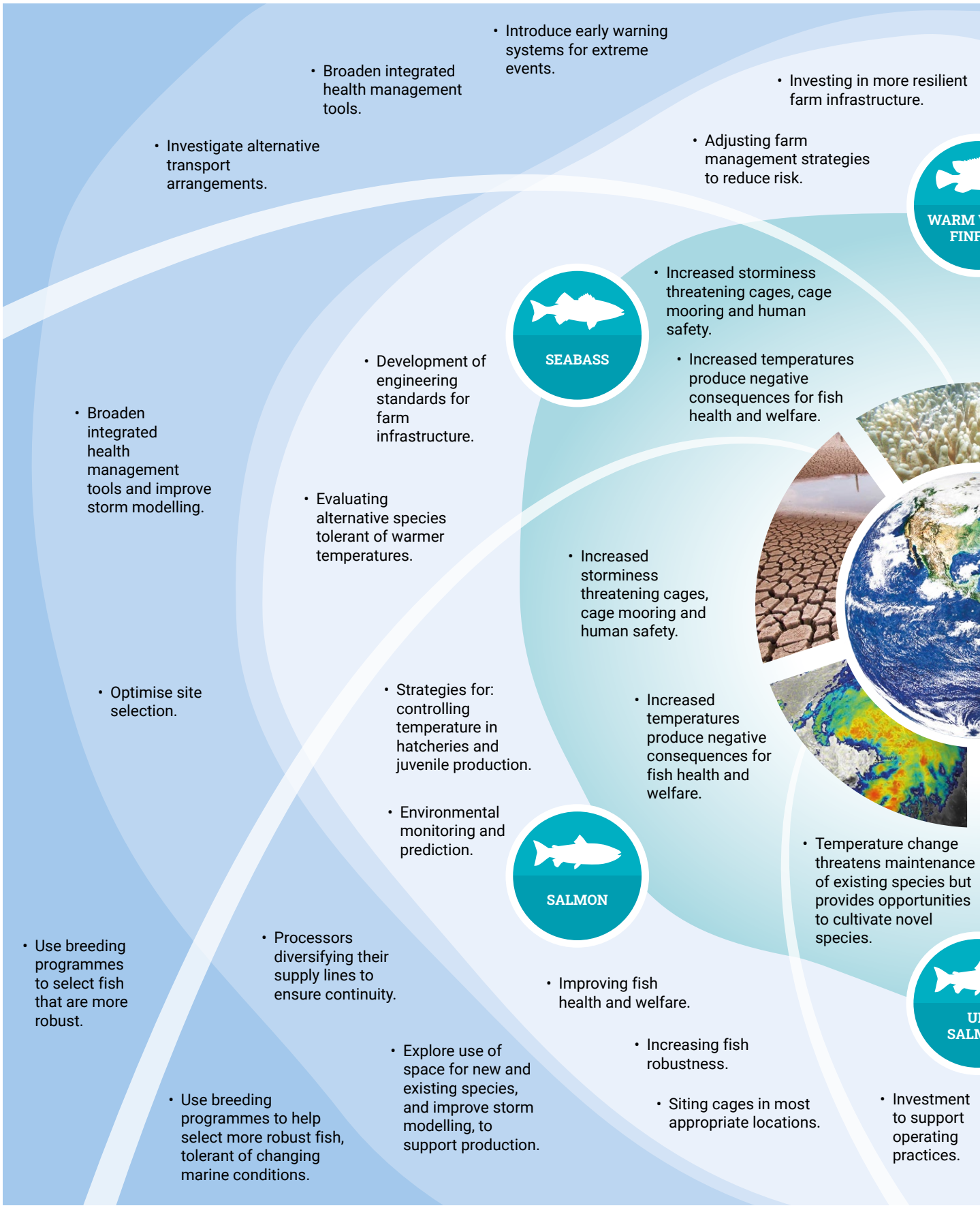
1. **Alteration of ocean ecosystems.** Effects of climate change and acidification are altering ocean ecosystems with potential for impacting *aquaculture* and *capture fisheries.* Key drivers include rising water temperature, rising levels of carbon dioxide uptake from the atmosphere and inadequate oxygen.
2. **Regional shifts in stock distribution.** To date, regional shifts have been less evident in the context *of aquaculture,* where some movement of non-native or invasive species has been reported. However, the effects have been more evident in *capture fisheries* where major changes in the distribution of some commercially important species of fish have been observed.
3. **Changing potential for catch and aquaculture production;** In *aquaculture* a range of climate change related events - floods, fluctuation in salinity, heightened risk of diseases, parasites and HABs) - are already impacting on industry e.g. lost production and infrastructure, reduced production due to the negative effects on farming conditions. Longer term consequences of changes in temperature, rainfall, ocean acidification, incidence and extent of low/depleted oxygen (hypoxia), and sea level rise will have positive and negative impacts. For example, prolonged periods of high temperature in localised areas around the UK may lead to a decline in productivity for some species but offer opportunities for others. Elsewhere there may be reduced availability of wild seed for shellfish production, or increased competition for freshwater (arising from reduced rainfall). Where these are experienced closer to the coast, this may be avoided where aquaculture is developed in more exposed/ offshore locations. Impacts on capture fisheries, including displacement of stocks and mortality of shellfish from more acidic water, are expected to be negative on a global scale, with projected changes and impacts varying substantially across regions.
4. **Increased storm severity and flooding impacting offshore, near-shore and onshore operations.** In *aquaculture,* increased storminess and wave impacts will test resilience of near- or offshore farms, on-growing structures may be damaged, the ability to operate sites may be compromised, and safety of staff and service vessels placed at increased risk. In *capture fisheries* these effects will test the resilience of vessel operation and vessels/ gear in harbour. For offshore fisheries, increased storminess and waves have implications for time at sea, safety at sea, and the effectiveness of vessels and gear. Onshore infrastructure such as piers, ports and harbours etc and support services, such as coastal processing and transport facilities, may also suffer damage and disruption.

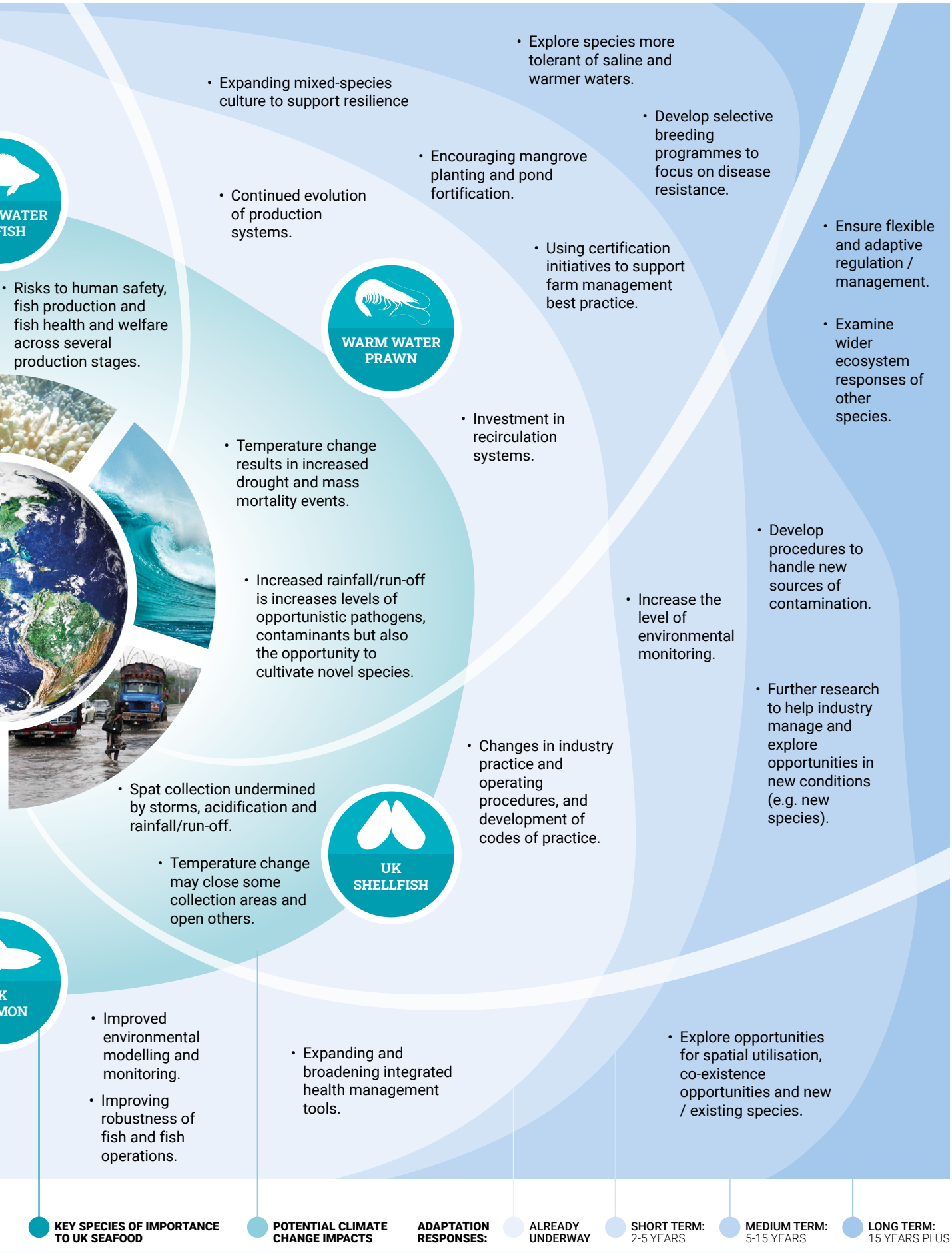
Industry perspectives

Those experiencing climate change acknowledge the uncertainty over climate change effects. With multiple factors in play, there is a feeling that it is too early to say what effects are due to climate change or simply 'weather'. It is acknowledged that effects will be non-linear and anticipating these will be complicated by species adaptation.

Understandably then, climate change is not a priority for some – particularly amongst smaller, owner-operators. Larger companies appear to have more awareness of, and engagement in, the climate change agenda. Similarly, vulnerability and capacity to respond (adaptive capacity) depends on scale of operation. With small producers having to respond to a range of immediate pressures just to maintain current business there is very little wherewithal or appetite to address climate change impacts. Operators of significant scale appear better positioned with action underway to meet some of the expected challenges. Notwithstanding these uncertainties, several adaptation responses are identified.

Fig 2.1 Climate change and UK seafood: Example impacts and adaptation responses in key sources of aquaculture production




WATER
FISH
• Risks to human safety, fish production and fish health and welfare across several production stages.
• Expanding mixed-species culture to support resilience
• Explore species more tolerant of saline and warmer waters.
• Develop selective breeding programmes to focus on disease resistance.
• Encouraging mangrove planting and pond fortification.
• Continued evolution of production systems.
• Using certification initiatives to support farm management best practice.
• Ensure flexible and adaptive regulation / management.
WARM WATER PRAWN
• Examine wider ecosystem responses of other species.
• Investment in recirculation systems.
• Temperature change results in increased drought and mass mortality events.
• Develop procedures to handle new sources of contamination.
• Increase the level of environmental monitoring.
• Increased rainfall/run-off is increases levels of opportunistic pathogens, contaminants but also the opportunity to cultivate novel species.
• Further research to help industry manage and explore opportunities in new conditions (e.g. new species).
• Changes in industry practice and operating procedures, and development of codes of practice.
• Spat collection undermined by storms, acidification and rainfall/run-off.
UK SHELLFISH
• Temperature change may close some collection areas and open others.
K
MON
• Improved environmental modelling and monitoring.
• Improving robustness of fish and fish operations.
• Expanding and broadening integrated health management tools.
• Explore opportunities for spatial utilisation, co-existence opportunities and new / existing species.
KEY SPECIES OF IMPORTANCE TO UK SEAFOOD
POTENTIAL CLIMATE CHANGE IMPACTS
ADAPTATION RESPONSES:
ALREADY UNDERWAY
SHORT TERM: 2-5 YEARS
MEDIUM TERM: 5-15 YEARS
LONG TERM: 15 YEARS PLUS

3. Key impacts and adaptation responses

This section identifies the key risks and opportunities affecting aquaculture sourced seafood from domestic and international locations.

Domestic system: key impacts and responses

Across ***finfish (salmon and trout) and shellfish (bivalves) production***, two main climate change drivers that lead to priority impacts are air/sea temperature change and changes in rainfall/run-off. In shellfish production, an additional driver is ocean acidification. These largely give rise to threats but also present some opportunities.

In domestic finfish (salmon and trout), climate drivers may threaten the ability to maintain existing species but could provide opportunities to cultivate novel species (in hatchery/nursery operations), may alter the occurrence / distribution of non-native species (in finfish farming), or have a negative effect on fish condition contributing to 'softer' fish and production inefficiencies (in processing). Responses that are already underway include strategies for industry investment to support operating practices, Government and scientific efforts to improve environmental modelling and monitoring, expansion and broadening of integrated health management tools and improved robustness of fish and fish operations. Proposed responses in the medium term include the need for industry, Government and scientists to explore opportunities for spatial utilisation, relating to co-existence opportunities and new and existing species.

In domestic shellfish (bivalves), climate drivers may undermine spat collection, potentially closing some collection areas and opening others (capture and/or broodstock cultivation), may result in the naturalisation of new or competitor species – an opportunity to cultivate new species but also a threat if detrimental to established native species (shellfish farming), or increase the risk of diseases / pathogens. Adaptation could be supported by action already underway: changes in industry practice and operating procedures, and development of codes of practice. Proposed responses in the short term include increasing the level of environmental monitoring to capture changes affecting the marine environment. In the medium term, procedures should be developed to handle new sources of contamination, with modelling and further research to help industry manage and explore opportunities in new conditions (e.g. new species). Longer term there is a need for flexible and adaptive regulation/management and to examine wider ecosystem responses of other species.

Aquaculture feed and ingredients: key impacts and responses

For ***aquaculture feed and ingredients***, an important climate change driver is air/sea temperature change. This may change the distribution or catch potential of target species and impact on international fisheries governance and access rights. This is expected to disrupt raw material sourcing, specifically activities in wild capture fisheries and seafood supply chain by-products. In responding to this, it is noted that significant industry effort is already underway to explore feed ingredient options – including alternative marine ingredients. In the short term, additional effort is needed to assess climate change impact on fishery biomass, to understand the different stressors in production systems and also to ensure international fisheries management regimes provide early resolution on 'rights to fish'. In the medium term, investment will be required to improve the resilience of coastal facilities and address potential disruption.

International system: key impacts and responses

In an international context, ***marine cage production of finfish (salmonids, sea bass and sea bream)*** could be strongly affected by two climate change drivers: increased storminess and waves and air/water temperature change. These could give rise to specific impacts for temperate salmonid production, and Mediterranean production of sea bass and bream.

In marine cage salmonid production, climate drivers such as storminess may threaten cages, cage mooring and human safety, whilst increased temperature could have negative consequences for fish health and welfare. Many supportive actions are already underway including strategies for: controlling temperature in hatcheries and juvenile production; environmental monitoring and prediction; improving fish health and welfare; increasing fish robustness; and siting cages in most appropriate locations. However, additional responses are identified. In the medium term these include processors diversifying their supply lines. To support production, the use of space for new and existing species should be explored, and storm modelling improved. Longer term, breeding programmes can help select fish that are more robust and tolerant of a wider range of conditions.

Similarly, in Mediterranean marine cage sea bass and bream production, climate drivers such as storminess may also threaten cages, cage mooring and human safety, with increased temperature having potential negative consequences for fish health and welfare. Responses already underway include the development of engineering standards for farm infrastructure and evaluating alternative species more tolerant of warmer temperatures. Suggested responses for the medium term include efforts to optimise site selection, broaden integrated health management tools and improve storm modelling. As with salmonids, longer term breeding programmes could be used to select fish that are more robust.

Also, in an international context, ***warm water production of freshwater finfish (e.g. pangasius, tilapia) and shellfish (prawn and shrimp)*** are expected to experience impacts from climate change drivers: temperature change and rainfall/run-off particularly. Each production stage is presented with several potential impacts; largely threats but also some opportunities.

In freshwater finfish (pangasius, tilapia), climate drivers could result in risks to human safety, fish production and fish health and welfare across multiple production stages. Adaptation could be supported by actions already underway; investing in more resilient farm infrastructure and adjusting farm management strategies to reduce risk. Suggested responses in the medium-term include investigating alternative transport arrangements, broadening integrated health management tools, and introducing early warning systems for extreme events.

In shellfish (prawn and shrimp), climate drivers could similarly generate risks to human safety, fish production and fish health and welfare across the production chain. For example, increased rainfall/run-off is expected to increase levels of opportunistic pathogens, contaminants etc but may offer the opportunity to cultivate novel species, whilst temperature change may result in increased drought and mass mortality events. Actions already underway - such as the continued evolution of production systems, and investment in recirculation systems - could support adaptation response to these impacts. Additional responses that could be progressed in the immediate term include expanding mixed-species culture to support resilience, encouraging mangrove planting and pond fortification, and using certification initiatives to support farm management best practice in climate response. In the medium term, species more tolerant of saline and warmer waters should be explored with selective breeding programmes developed to focus on disease resistance.

4. Next steps

This exercise has highlighted the differences in how the domestic and international industry will be affected by climate change. This will influence how seafood businesses and other stakeholders will need to respond.

The adaptation responses have been identified through engagement with stakeholders, and involve individual, industry, government action as well as collaborative approaches. There is already some partnership working, but many of the proposed responses require further collaboration and understanding on all sides.

Recommended pathway for adaptation

In adapting to climate change, important barriers need to be recognised. Climate change is an *emergent* challenge, not wholly understood. Climate change is one of many challenges facing the seafood industry and competes with other priorities. Finally, successful adaptation is subject to a wide range of interdependencies: within seafood supply chains; across aquaculture, feed and ingredients, and wild capture; between domestic and international systems; and between sectors e.g. seafood and agriculture.

The scale of the resource required differs between responses, and delivery can in some cases require several organisations to work together as 'response owner'.

Several *adaptation principles* are recommended. These include:

- 'Industry demand-led actions' to ensure there is clear expression of industry demand for progressing responses closely tied to industry operation.
- 'Boundary spanning' support provided by the likes of Seafish, SSPO, MCCIP and others to bring stakeholders together.

Specific *adaptation responses* should fall within the corporate planning process of the relevant 'owner' stakeholder. An adaptation 'framework' rather than a centralised 'grand' plan for the industry is recommended. A framework would better accommodate the range of stakeholders and diversity in industry supply chains, particularly as climate change impacts and adaptation responses may not be directly linked. Such a framework would see:

- Adaptation responses brought into existing corporate planning processes of each stakeholder.
- High-level monitoring.
- Regular review of climate change and adaptation responses.

Suggested next steps for aquaculture stakeholders

A number of conclusions and next steps are suggested for aquaculture stakeholders. These are to:

- Review adaptation responses in the full report and operationalise as necessary
- Review the appropriateness of an adaptation framework for aquaculture
- Use this assessment as the central contribution to future aquaculture adaptation plans
- Maintain an understanding, and raise awareness, of relevant climate change impacts and progress appropriate response options.

Further information and keeping up-to-date

Seafish and SSPO support industry stakeholders in responding to changes in the industry landscape through their corporate governance arrangements. These include various industry panels and groups, which meet regularly to review industry concerns. For more information, please visit www.seafish.org and https://www.scottishsalmon.co.uk/

This brief report is a synopsis of the full report *Understanding and responding to climate change in the UK seafood industry: Climate change risk adaptation in aquaculture sourced seafood* (available from Seafish). Full details of the bibliography, consultees and further reading can be found within the full report.

This document has been produced by Dr Angus Garrett, Lee Cocker and Craig Burton (Seafish), Iain Berrill and Jamie Smith (Scottish Salmon Producers Organisation), Dr Lynne Falconer, Dr Trevor Telfer, and Dr Bruce McAdam (Stirling University), and Dr John Pinnegar (CEFAS).

Readers' comments on the content of the publication are welcomed. Please contact Angus Garrett on 0131 524 8697 or by email angus.garrett@seafish.co.uk

This document combines data, opinions and conjecture and is a position paper at the time of press. It is important to bear in mind that evidence today might suggest trends that turn out to be very different in the longer-term.

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