Seafood Strategic Outlook
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MCCIP Marine Climate Change Impacts Partnership

Climate change adaptation in UK seafood: Understanding and responding to climate change in the UK wild capture seafood industry

SEAFISH
the authority on seafood

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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.

Introduction

This summary report is focussed on climate change adaptation for the UK wild capture seafood industry. It considers the major industry impacts arising from key climate change drivers and sets out major areas where adaptation action may be required.

This exercise, conducted in 2014/15, 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 seafood.
- Identifies relevant seafood industry adaptation responses (these responses will rest with industry bodies and others to take forward).

The Seafish mission is to secure a profitable, sustainable, and socially responsible future for the UK seafood industry. An important underlying function for Seafish in achieving this mission is to help *protect* the industry in the face of natural and man-made risks and challenges. Climate change and adaptation is a strategic challenge facing the industry, and this review is an important part of responding to that.

For an industry based on the exploitation of a natural resource, consideration of scientific and commercial issues around 'sustainability' is the norm. Climate change has potentially direct consequences for the sustainable exploitation of wild capture fisheries, affecting both the fishery resource, as well as the onshore and offshore operations that support the industry. This document focusses on the impacts of climate change on the abundance and distribution of wild stocks, capture/production, transport and distribution, and processing. It covers whitefish, pelagic and shellfish species of commercial importance to the UK wild capture seafood industry and includes fish landed both within and outside of the UK. This work does not cover market/sales outlets, consumption and waste.

The report has been produced by Seafish in collaboration with the Marine Climate Change Impacts Partnership (MCCIP), with input from the across the UK seafood industry. Focussing on UK wild capture seafood (domestic and international), the exercise relied on research evidence and industry experience (engaging around 40 stakeholders). The full report was submitted to the UK Government under the Climate Change Adaptation Reporting Power and is available from Seafish.

Contents

1. 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 the global scale, the most authoritative source of information on climate change continues to be the periodic assessment reports produced by the Intergovernmental Panel on Climate Change (IPCC), established in 1988. In the UK, the Marine Climate Change Impacts Partnership (MCCIP) has been collating scientific evidence on coastal and marine climate change impacts since 2006.

It is widely reported that impacts of climate change are having significant impacts on marine ecosystems, with knock-on effects for fisheries, and that onshore and offshore infrastructure is at risk from changes in sea level, storms and waves etc. Impacts will affect all stages of the seafood system to a greater or lesser degree.

The main physical climate change drivers of relevance to the industry are:

- **Sea level rise and changes in extreme water levels,** increasing the risk of coastal flooding of onshore infrastructure supporting the industry (e.g. at ports and harbours).
- **Changes in storms and waves,** potentially leading to increased damage of port infrastructure and affecting safety (and time) at sea.
- **Changes in sea temperature,** affecting catch potential for important wild capture species landed in the UK (with an increase in warm versus cold water species), and internationally (see Figure 1.1).
- **Ocean acidification and de-oxygenation of sea water,** with implications for fish in low oxygen waters and shellfish where acidification affects their ability to form shells.
- **Changes in terrestrial rainfall** leading to surface flooding of land-based infrastructure, and altering the rate and volume of contaminant and pollutant transfer from land to sea.

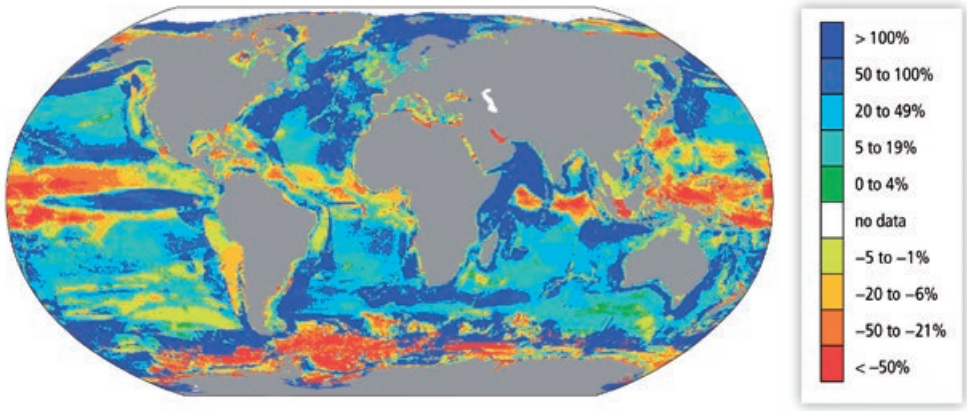

Figure 1.1 Projected global redistribution of maximum catch potential of around 1,000 exploited fish and invertebrate species1 (Source: IPCC, 2014)

Main implications for the seafood industry

The main impacts on the industry, both domestically and internationally, are based around changing catch potential, as well as damages from changing storm and flood frequency and severity. With regards to the impacts on catch potential, it is argued that the impacts of climate change on fishery resources are exacerbated by factors such as overfishing, habitat loss and pollution.

For domestic aspects (i.e. affecting fish landed in the UK and its supporting infrastructure), there is a finer level of detail available on local conditions affecting fishery resources (both onshore and offshore), as well as operating conditions. For international aspects, a greater emphasis is placed on broader scale regional patterns of fishery resource availability and international food security issues.

The issues listed below are relevant to both domestic and international industry:

1. **Changing catch potential.**
   Major impacts are anticipated from the displacement of stocks (see figure 1.1). For international wild capture, the overall projected impacts on fisheries are negative, and severely so in lower latitudes and the Southern Ocean. In other areas it is projected that fish stocks will increase. For domestic wild capture, there will be both winners and losers as fish stock distributions change. Warming is expected to lead to further declines in traditional domestic cold-water species (e.g. cod and haddock), whilst warm-water species become more abundant (e.g. John Dory, squid, anchovy and red mullet).

   Impacts on mortality of shellfish from more acidic water, increases in harmful algal blooms, ocean dead zones and coral reef destruction are also potential issues, particularly for international wild capture fisheries.

2. **Regional shifts in stock distribution.**
   The migration of commercial species in response to climate change will challenge the existing agreements between governments over fisheries regulations. An example of the impact of stock migration is the recent movement of Atlantic mackerel to Icelandic waters which has led to Icelandic and Faroese vessels fishing this stock outside of an international management agreement.

3. **Impacts on offshore operations and assets.**
   Any increase in storm intensity and frequency could increase the risk of damage to boats, especially smaller vessels, and potentially put lives at risk. Deployment and performance of gear is also adversely affected in stormy conditions. The 'catchability' of some target species is affected by both stormy conditions and temperature regimes due to effects on fish depth and visibility (e.g. for line fisheries).

4. **Impacts on onshore operations and assets.**
   Sea level rise and surge events, as well as extreme storms and waves could damage, or cause widespread disruption to onshore operations and assets. This includes damage to port and harbour assets (including boats), fish processing sites and local housing and amenities. At the local level, changes in terrestrial rainfall could increase flood threats to onshore operations. Extreme events could also disrupt onshore operations through loss of days at sea, impacts on transport routes (e.g. roads and ferries) and loss of electricity supply at ports and harbours and processing sites.

Industry perspectives

Impacts from a range of climate related events are widely acknowledged by the industry. Recent stormy conditions, for example those experienced in UK during the winter of 2013/14, have limited time at sea for some vessels and caused damage to boats and gear, as well as to port and harbour infrastructure. Changes in sea temperature are known to affect the abundance and distribution of commercial fish species. Domestically, this can be seen through changes in stocks of warm-water species (e.g. squid, sea bass) compared to cold-water species (e.g. cod and haddock). Internationally, moving fish stocks have contributed to disagreements over quota (e.g. mackerel in the North East Atlantic) and could affect from where key import species (e.g. prawns and tunas) can be sourced.

Whilst the industry acknowledges impacts from near-term climate related events (i.e. storms, flooding, changing fish distribution, etc.), these from part of a range of risks and uncertainties the industry routinely faces. Such inherent unpredictability is a constraint to taking a longer view and planning ahead, and action to adapt to climate change is largely a low priority when compared to other imperatives. The perceived relevance of climate change to business planning and investment; regulation, environment and ethics; access to supplies; and planning constraints (e.g. catch quota) will also vary across the industry, according to factors such as organisational size, scale of investments and position in the supply chain.

2. UK seafood industry

The UK seafood industry, being reliant on wild capture and aquaculture produced raw material, is diverse, complex and dynamic. The seafood industry can be considered 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 – *defined as a system reliant on domestically sourced material (material caught from North Atlantic stocks and landed in the UK, material farmed in the UK).* Within the 'domestic system', the key UK actors are: vessels, agents and merchants in the UK handling material landed/farmed in the UK; UK processors of fish; and the downstream supply chain in the UK of all of the former including food service companies, retailers and exporters.
- An international system – *defined as a system reliant on internationally sourced material (material caught from stocks in the North Atlantic and elsewhere landed outside the UK, material farmed 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 or farmed and possibly processed outside of the UK; UK processors of imported fish; and the downstream supply chain in the UK of all of 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 (cod, haddock and Alaska pollock), pelagics (tunas) and shellfish (cold-water prawn and farmed warm-water prawn). Meanwhile, UK landings volumes are dominated by mackerel and herring (pelagics), Nephrops (shellfish) and cod and haddock (whitefish).

This exercise is concerned with wild capture seafood only. Being concerned with a natural resource, the wild capture industry is inherently uncertain. Perhaps unsurprisingly the industry, dealing with day-to-day realities, in highly *uncertain* conditions, does not tend to think far ahead (often a forward view is no more than one year ahead).

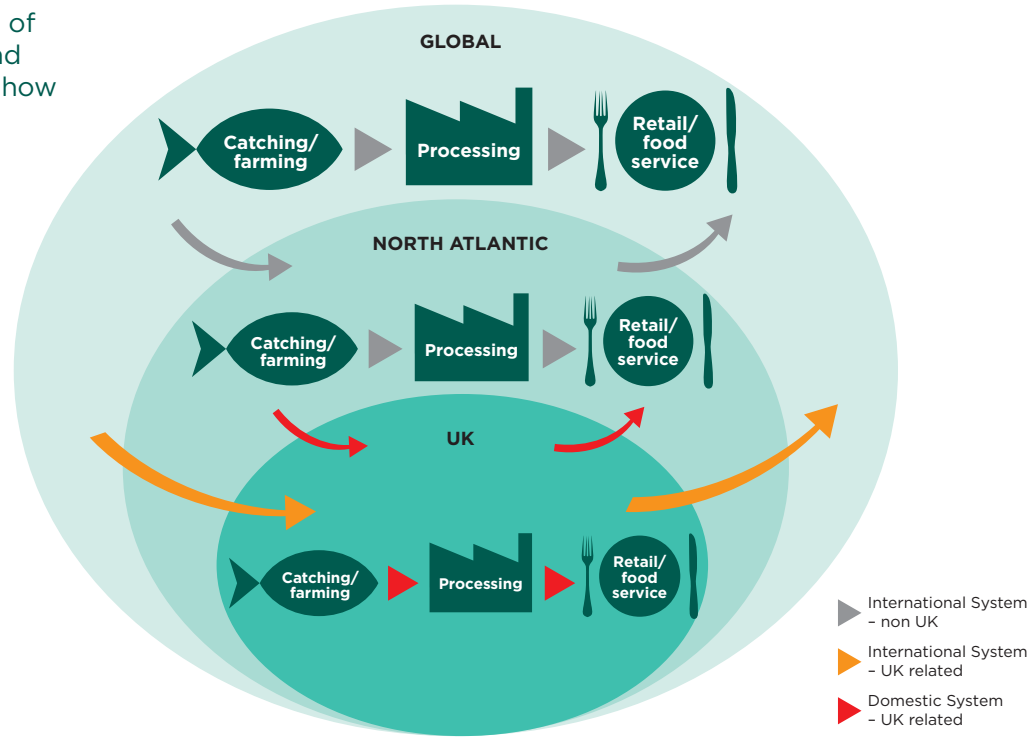

Figure 2.1 Components of the UK international and domestic systems and how they are interrelated.

3. Key impacts and responses (with case examples)

This section identifies the key risks and opportunities affecting domestic and international aspects of the UK wild capture industry in turn (see tables below). The tables are based on a detailed risk assessment exercise, drawing on academic research and industry experience. Key risks (red dots) and opportunities (green dots) highlighted are those that could require attention in the near term and/or have the most widespread impacts. Climate change forms part of a range of risks and uncertainties that the industry routinely faces, nevertheless a number of adaptation responses are identified.

For domestic aspects, there is a finer level of detail available on local conditions affecting fishery resources, as well as operating conditions. For international aspects, a greater emphasis is placed on broader scale regional patterns of fishery resource availability and international food security issues in the tables below.

Domestic system: key impacts

In a UK domestic context, across whitefish, pelagic and shellfish capture fisheries, the two main climate change drivers that lead to priority risks are *increased storminess and waves* and *air or sea temperature change*. In shellfish fisheries, an additional driver is *changes in rainfall/land run-off.*

These give rise to both threats and opportunities. For example in whitefish and pelagic fisheries there are threats and opportunities presented by changes to distribution of target species, as some traditional species may move away, and warmer water species move in. An example in shellfish fisheries are the threats and opportunities generated by increases or decreases in the prevalence of non-native species/jellyfish. Onshore, the two main drivers similarly lead to priority risks but are compounded by *sea level rise and extreme water levels* and *changes in rainfall/land run off.* A number of threats arise for onshore operators, including damage to site infrastructure (ports and processors), integrity of electricity supplies, transport disruption (including ferries), integrity of housing and reduced employment.

OFFSHORE	Sea level rise, extreme water levels	Increased storminess and waves	Air or sea temperature change	Ocean acidification and deoxygenation	Changes in rainfall / run off
WHITEFISH					
a) Fishery resources					
i. Alterations in species phenology			🔴		
ii. Impacts on choke species (linked to landing obligations)			🔴🟢		
iii. Changes to growth rate of target species			🔴🟢		
iv. Changes to the distribution of target species			🔴🟢		
v. Changes to year-class strength (including larval survival)			🔴🟢		
vi. Migration patterns of target species (timing and routes)			🔴🟢		
b) Offshore operations					
i. Staff physical working conditions		🔴			
ii. Gear deployment / performance		🔴			
iii. Damage to fleet		🔴			
PELAGIC					
a) Fishery resources					
i. Migration patterns of target species (timing and routes)			🔴		
ii. Alterations in species phenology			🔴		
iii. Changes to the catchability of target species		🔴	🔴		
iv. Changes to growth rate of target species			🔴🟢		
v. Changes to the distribution of target species			🔴🟢		
vi. Changes to year-class strength (including larval survival)			🔴🟢		
b) Offshore operations					
i. Staff physical working conditions		🔴			
ii. Gear deployment / performance		🔴			
SHELLFISH					
a) Fishery resources					
i. Presence of HABs		🔴	🔴		🔴
ii. Presence of pests and diseases					🔴
iii. Changes to year-class strength (including spatfall)			🔴🟢		
iv. Presence of non-natives / jellyfish			🔴🟢		
v. Changes to the distribution of target species (including squid)			🟢		
vi. Changes to growth rates of target species			🔴🟢		
b) Offshore operations					
i. Staff physical working conditions		🔴			
ii. Gear deployment / performance		🔴			
iii. Damage to fleet		🔴			
ONSHORE					
a) Ports and harbours					
i. Damage to site infrastructure	🔴	🔴			🔴
ii. Boat damage in ports / harbours		🔴			
iii. Integrity of electricity supply					🔴
b) Employment and fishing communities					
i. Integrity of housing and local amenities	🔴	🔴			
ii. Days at sea		🔴			
c) Transportation of catch					
i. Disruption to ferry service		🔴			
d) Processing of catch					
i. Damage to site infrastructure	🔴	🔴			🔴
ii. Integrity of electricity supply					🔴

Table 3.1 Summary of key domestic offshore and onshore threats (red dots) and opportunities (green dots)

Domestic system: adaptation responses

In the UK domestic context, responses in offshore fisheries that are currently underway include improved scientific advice and data collection through partnership working. However, adaptation requires much closer science-industry collaboration and engaged research in the short term, and a move towards a more robust and strategic fisheries knowledge base in the medium term. Governance of fisheries (including regulated ('Relative Stability') and non-regulated species) should also be examined in the short, medium and long term particularly given the need for institutional arrangements to be able to respond in the face of climate change. Vessel owners are already enhancing operational safety, and in the short term need to keep a watching brief on how climate change is affecting fisheries. Longer term, fleet wide vulnerability should be reviewed. Onshore, port authorities in the UK are investing in actions to build port resilience but should improve risk management. The vulnerability of freight ferries should be assessed. Short term action to improve marketing of seafood is required at the processing stage; longer term there may be a requirement to relocate processing sites inland.

		System	Adaptation response	Owner	Scale of resource			
					Minor	Moderate	Significant	Major
Speed of response (inertia)	**Underway**	**Fishery**	Scientific advice and data collection through partnership working	Fisheries Science Partnerships				
		Fishery	Development of training and education modules for fishermen	Fishing into the Future (with Seafish)				
		Operations	Enhance operational safety (raised decks)	Industry				
		Operations	Enhance operational safety (Personal Flotation Devices)	The Fishing Industry Safety Group				
		Operations	Enhance operational safety (Safety at Sea training)	Seafish-approved training providers				
		Ports	Build port resilience	Port / harbour authorities / Department of Transport				
		Processing	Develop markets for available domestic seafood	Seafood Scotland				
	Immediate (<2 years)	**Ports**	Ensure berth allocations for vulnerable vessels	Port / harbour authorities				
		Processing	Develop marketing strategies for seafood in rest of UK	Industry trade organisations				
	Short term (2-5 years)	**Fishery**	Develop close science-industry collaboration and engaged research	Industry trade associations / scientists				
		Fishery	Ensure quota swaps / transfers	Industry				
		Operations	Keep a watching brief on climate change and potential responses	Industry trade associations				
		Ports	Improving port risk management	Port / harbour authorities				
		Transport	Assess vulnerability of freight ferries	Government				
		Processing	Establish specific seafood marketing organisations for rest of UK	Industry trade organisations (e.g. Fishmongers Hall)				
	Medium term (5-15 years)	**Fishery**	Developing a more robust, strategic fisheries knowledge base.	Scientists / industry / Govt				
		Fishery	Review of domestic quota allocation	EU / UK Govt / Fisheries scientists / industry				
		Operations	Review of fishing seasons in response to disruptions	Industry / Government				
	Long term (>15 years)	**Fishery**	Review 'Relative stability' (Governance) arrangements	EU / UK Govt / Fisheries scientists / industry				
		Operations	Assess vulnerability of fleets across the EU	EU research				
		Processing	Re-locate processing sites inland	Processors and planning inspectorate				

Table 3.2 Adaptation responses for the domestic system

Case 1. Climate change (temperature change) and wild capture fish and shellfish stocks

What is the issue?

Changing climatic conditions have been linked to changes in the abundance and distribution of commercial fish stocks of relevance to the domestic system. In some cases this is leading to new (e.g. boarfish) or enhanced opportunities to exploit 'warm-water' commercial stocks (e.g. squid, John Dory, seabass, red mullet and anchovy), whilst more traditional 'cold-water' stocks become increasingly threatened (e.g. cod and haddock).

Examples:

- A recent expansion in the abundance of boarfish (which only Denmark, Ireland and UK have quota for) could be linked to climate change, leading to new commercial opportunities. For example, Ireland has now opened markets to China.
- Off north-east Scotland, where most squid is found, more boats are now trawling for squid than the region's traditional target species, such as haddock and cod.

Case 2. Climate change (temperature change), changing fish distributions and their implications for quota management

What is the issue?

The impact of climate change on fish species distribution has the potential to lead to international disagreements as stocks move across international boundaries. There are not only issues with non-EU countries declaring quota, but also the mal-adaptation of EU quota systems under 'relative stability' which lacks the flexibility to respond to geographical shifts of fish species.

Example:

- Recent disagreements over mackerel quotas when the species had suddenly attained high abundance in Icelandic and Faroese territorial waters. This development requires a broadening of the parties involved in the quota agreement for mackerel but as yet this remains unresolved. It is not clear if mackerel are spreading out or shifting distribution (by 2014 mackerel had reached as far as Greenland), but either way it is important to understand the role of climate change given the political implications for quota allocations.

Case 3. Climate change (increased storminess) and impacts on onshore and offshore operations

What is the issue?

Changes in the frequency and intensity of storms have the potential to cause major disruption to both onshore and offshore operations. On land, port and harbour infrastructure, as well as day-to-day operations, can be adversely affected by storms, as can processing plants and transport routes to market. At sea, the ability to go out to fish, especially for smaller vessels, is an issue, as is the safe deployment and performance of gear.

Examples:

- Recent storms have led to substantial physical damage to port infrastructure (e.g. the lighthouse and other properties at Fraserburgh, as well as over-topping of sea defences at Peterhead, damaging equipment and housing). The port authority at Peterhead is already investing in higher sea walls.
- The winter of 2013-14 was extremely stormy, especially in south of the UK, which meant boats were stuck in port for long periods.
- In the pelagic sector storminess and waves are already seen to be making an impact. Waves are threatening crew on deck where fish are being pumped aboard from alongside. A number of vessels have built a raised deck and placed the pump higher so that crew members are away from swells (and clear of danger). New build vessels are relocating the pump to the stern i.e. pumping fish from aft as this is safer than pumping from alongside.

Case 4. Climate change (acidification and deoxygenation) and its consequences for marine fisheries

What is the issue?

Ocean acidification, the result of increasing carbon dioxide uptake by ocean waters from the air, leading to reduction in pH, presents a threat to the future of commercially important fish and shellfish stocks. Increased acidification is likely to become especially marked in Arctic and sub-Arctic waters.

For warm water corals, if CO2 emissions continue rising at the current rate, coral reef erosion is likely to outpace reef building before the end of this century. Coral bleaching as a result of rising temperatures is also expected to increase, with resulting loss of support and habitat for fisheries.

Examples:

- *Adverse effects on some marine ecosystems,* e.g. lower pH, in combination with rising temperature could affect fish habitats linked to cold water coral e.g. evidence of an adverse impact on recruitment to fish stocks in Western Norway, and for warm water coral reefs, impacts on ecosystems and the potential collapse of some related coastal fisheries.
- *Vulnerability of early life stages of fish* (eggs, larvae) to change in pH as well as changes in the plankton community reducing survival in the early life stages due to effects on food quality and quantity, timing (match/mismatch in timings of food supply and demand) and predation.
- *Vulnerability of shellfish* e.g. seasonal upwelling of acidic waters onto the continental shelf in the California Current region adversely affecting oyster hatcheries on the coasts of Washington and Oregon in the United States.

Case 5. Climate change (temperature change) and cold water prawns

What is the issue?

Warming in the Arctic and North Atlantic (traditional sources for UK cold water prawns) may be contributing to recent declines in cold water prawn stocks. In addition, reductions in Arctic sea-ice may lead to a new, ice-free, stratified and completely unknown ecosystem in the coming decades which could lead to changes in the stock. This might include an increase in stock in Russian waters and declines in other areas.

Examples:

- Changes in temperature and ice cover could mean that prawns (and other fish species) can feed over a larger area.
- Climate change may favour cold water prawns in new productive regions, whilst more southerly areas may lose out.
- Like other bottom-dwelling forms, prawns depend on primary production and what is 'left over' in the upper water column and sinks to the bottom.

Case 6. Climate change (temperature change, acidification and deoxygenation) and tuna fisheries

What is the issue?

Tuna is a highly migratory species, swimming through international waters and waters belonging to many countries. Growing evidence of climate-related changes in the distribution of commercial fish stocks challenges the present fishery and ecosystem management arrangements of Regional Fisheries Management Organisations (RFMOs). Shifting stocks may lead to conflicts between industrial foreign fleets and national ones restricted to their Exclusive Economic Zone (EEZ).

Examples:

- Changes in temperature, oxygen levels and food availability in the ocean are all likely to alter the distribution and abundance of top predator species such as tuna in the Pacific and Indian Oceans: in general, stocks in both oceans are predicted to shift eastwards.
- The Western and Central Pacific Fisheries Commission have already discussed adaptation to climate variability and change that affects the tuna fisheries. It identified the importance of improving models, forecasts and projections of tuna stocks in order to assess the full socio-economic implications of changes in tuna catches and adjust adaptation plans with the aim of minimising threats and maximising opportunities.
- Based on SEAPODYM (Spatial Ecosystem and Population Dynamics Model), the distribution of skipjack tuna in the Pacific is projected to extend further eastward over time, with catches eventually decreasing in the west. The stock of bigeye tuna is expected to decrease across the region.

International system: key impacts

In an international context, across whitefish, pelagic and shellfish capture fisheries, the same two climate change drivers lead to priority risks i.e. *increased storminess and waves* and *air or sea temperature change.* For the international system, *ocean acidification and deoxygenation* is highlighted as a high risk climate driver for shellfish.

For whitefish and pelagic fisheries, changes in air or sea temperature suggest some impacts that could be both threats and opportunities, for example in terms of changes to distribution of target species. For shellfish fisheries, risks are generated by the introduction of non-native species but also, through acidification impacts on target species.

Onshore, risks are compounded by *sea level rise and extreme water levels* and *changes in rainfall/ land run off.* This gives rise to threats for onshore operators such as damage to site infrastructure (including vessels and gear) and coastal processing facilities. In some instances, changes in fisheries may impact on national economies and food security for the country of origin.

OFFSHORE	Sea level rise, extreme water levels	Increased storminess and waves	Air or sea temperature change	Ocean acidification and deoxygenation	Changes in rainfall / run off
Wild capture (general)					
i. Changes in species distribution and fisheries productivity (+ve and -ve effects)			🔴🟢		
ii. Loss of fisheries production at lower latitudes			🔴		
iii. Enhanced fisheries production at high latitudes			🟢		
iv. Impact on international fisheries governance and access rights			🔴		
WHITEFISH					
a) Fishery resources					
i. Changes in distribution or catch potential of target of species (general)			🔴🟢		
- Arctic fisheries			🔴🟢		
- North Atlantic Fisheries			🔴🟢		
- North Pacific (Alaska and Bering Sea) fisheries			🔴🟢		
- Mid Atlantic – offshore Senegal, The Gambia, Sierra Leone, Ghana			🔴		
b) Offshore operations					
i. Gear deployment / performance		🔴			
PELAGIC					
a) Fishery resources					
i. Changes in distribution or catch potential of target species (general)			🔴		
- Tuna fisheries			🔴		
- Pacific Ocean anchoveta and sardine fisheries			🔴		
SHELLFISH					
a) Fishery resources					
i. Changes in distribution or catch potential of target species				🔴	
ii. Introduction of non-native species			🔴		
b) Offshore operations					
i. Staff physical working conditions		🔴			
ONSHORE					
a) Ports and harbours					
i. Damage to site infrastructure	🔴	🔴			🔴
ii. Vessels / gear damage in ports / harbours		🔴			
c) Onshore processing					
i. Disruption or damage to coastal processing facilities	🔴	🔴			🔴
SOCIO-ECONOMIC CONDITIONS					
i. Impact on national economies of changes in fisheries			🔴🟢	🔴	
ii. Impact on food security of changes in fisheries			🔴	🔴	

Table 3.3 Summary of key international offshore and onshore threats (red dots) and opportunities (green dots)

International system: adaptation responses

For an industry operating in an international context, responses in offshore fisheries include an immediate review of key sources of existing supply and available options. In the short term, the impacts of changes in specific regional supplies should be monitored and assessed, whilst in the medium term the viability of enhanced regional productivity should be considered. Adaptation requires action in the short term to develop much closer science-industry links that can better understand climate driven regional changes in the Arctic, North Atlantic and Pacific and Indian oceans. In the face of changing fisheries, the governance of fisheries should be reviewed in the short term to ensure the concept of climate change adaptation is embraced and ensure international management regimes provide early resolution on 'rights to fish'.

In the medium term, adaptation should be enhanced through active engagement with overseas stakeholders. For overseas fleets, action currently underway includes enhancing operational safety, proposed action in the short term includes incorporating climate change in vessel and gear design and investment decisions (to maintain ability to catch and capacity to respond to enhanced productivity). Onshore, proposed responses in the short term concern the processing stage; a focus on improved resilience and capacity of overseas facilities (including modelling of extreme events on facilities but also ensuring flexibility over sources of fish and contingency planning).

		System	Adaptation response	Owner	Scale of resource			
					Minor	Moderate	Significant	Major
Speed of response (inertia)	**Underway**	**Offshore**	IMO convention on standards of training and certification of 'watchkeepers' (fishing sector)	IMO				
	Immediate (<2 years)	**Fishery**	Review of key sources of existing supply and available options	UK Industry - especially integrated supply chains / UK Govt / scientists				
	Short term (2-5 years)	**Fishery**	Monitoring and assessing the impact of changes in specific regional supplies	UK industry bodies / Support organisations / Govts / scientists				
		Fishery	Promoting an awareness of climate change in the North Atlantic pelagic fishery	UK Industry / UK Govt / scientists				
		Fishery	Ensure management regimes embrace the concept of climate change adaptation	International industry bodies / Govts / scientists				
		Fishery	Ensuring international fisheries management regimes provide early resolution on 'rights to fish'	Industry bodies / RFMOs / scientists / Govts.				
		Offshore	Maintain ability to catch	UK and international industry / marine engineers and designers				
		Offshore	Ensure capacity for enhanced productivity of whitefish fisheries at higher latitude	UK and international industry / scientists				
		Processing	Improve resilience and capacity of overseas facilities	UK and international industry / Govt / RFMOs / scientists				
	Medium term (5-15 years)	**Fishery**	Assessing the viability of enhanced regional productivity	UK industry / Govt / scientists				
		Fishery	Developing much closer science-industry links to understand climate driven regional changes	UK industry / Govt / scientists				
		Offshore	Engagement with overseas stakeholders to support climate change adaptation	UK industry / industry bodies / investors / RFMOs / scientists / Govts				
		Processing	Maintain a watching brief on climate change and potential responses overseas	UK industry / Govt / scientists				
	Long term (>15 years)		-					

Table 3.4 Adaptation responses for the international system

4. Next steps

This exercise has shown there are differences in how the domestic and international industry will be affected by climate change (see tables 3.1 and 3.3). This will shape how operators and support organisations will need to respond (see tables 3.2 and 3.4).

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

Adaptation will be challenging. Climate change is a relatively low priority for the industry, and successful adaptation is subject to a wide number of interdependencies.

Recommended responses

For domestic industry, in the short term, it is important to ensure that fishing vessels have safe berths and assess freight vulnerability to extreme weather, and to improve the marketing of seafood at the processing stage. Scientific advice is already improving particularly through partnership working with industry, although in the medium term this could be built upon to move towards a more robust strategic fisheries knowledge base. Longer term, fisheries management (governance) arrangements for all species should be reviewed to ensure that industry is able to respond and adapt to climate change.

For the international industry, an immediate response is to complete a review of key sources of existing supply and the options available. In the short term, changes in regional supplies should be monitored and assessed, along with closer industry-science cooperation to understand the climatic changes across the oceans. As with the domestic industry, a review of fishery governance should be carried out to ensure that catch levels can be maintained in the long term.

Recommended pathway for adaptation

In adapting to climate change, important barriers need to be recognised. Climate change is uncertain and the wild capture industry inherently unpredictable. Climate change is a relatively low priority for the industry, and successful adaptation is subject to a wide number of interdependencies. The scale of the resources required differs between responses and in some cases there are a number of organisations identified as ‘response owners’.

A number of *adaptation principles* are recommended. These include:

- ‘Industry demand-led actions’ which are implemented only with a clear and specific expression of industry demand, such as risk modelling and contingency planning, and development of new markets.
- ‘Boundary spanning’ support such as horizon scanning and communication, provided by organisations such as Seafish and MCCIP to bring stakeholders together and combine experience and scientific information to produce concrete actions.

Specific *adaptation responses* should fall within the corporate planning process of the relevant ‘owner’ stakeholder. Given the range of stakeholders, variation in resources and interdependencies, a climate change adaptation framework is recommended, which will allow for each owner to embed the responses into their management processes, rather than a centralised ‘grand’ plan. Such an adaptation framework should:

- Integrate adaptation responses into existing corporate planning processes of each stakeholder.
- Manage and maintain high level monitoring.
- Regularly review adaptation responses across industry domains and stakeholders.
- Maintain an ongoing review of climate change impacts.

It is recommended that:

- High level monitoring and regular review of adaptation responses across industry domains and stakeholders is undertaken. Given the UK industry support remit, Seafish may wish to consider playing this role.
- An ongoing review of climate change impacts on wild capture fisheries is maintained. The Marine Climate Change Impacts Partnership (MCCIP) already conducts reviews on all aspects of the marine environment. As these reviews are updated in the future, MCCIP may wish to consider how relevant outputs are made more readily available to the industry.

Initial resources allocated to adaptation should be moderate (reflecting industry priorities) with adaptation responses appraised, monitored and evaluated as to whether they support longer term decision-making and 'future-proof' the industry.

Further information and keeping up-to-date

Seafish supports industry in responding to issues and risks through its corporate governance arrangements. These include a number of industry panels, which meet regularly to review industry concerns. **For more information on the work of Seafish please visit www.seafish.org, and for more information on longer term issues contact Angus Garrett at angus.garrett@seafish.co.uk.**

MCCIP (The Marine Climate Change Impacts Partnership) produces regularly updated reviews of the impacts of climate change on fish and fisheries, as well as supporting industry adaptation. **Please visit www.mccip.org.uk for more information on the work of MCCIP. To request the latest review papers on climate change and fisheries, contact Paul Buckley at office@mccip.org.uk.**

FAO (United Nations Food and Agriculture Organisation) publishes the regular 'State of World Fisheries and Aquaculture' report and works with the Global Partnership Climate, Fisheries and Aquaculture (PaCFA), to raise awareness of climate change issues and to promote a coordinated response from the wild capture fisheries and aquaculture sectors.

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 for wild capture seafood* (available from Seafish). Full details of the bibliography, consultees and further reading can be found within the full report.

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MCCIP Marine Climate Change Impacts Partnership

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